2 DESCRIPTION AND COMPARISON OF ALTERNATIVES

Alternative strategies have been evaluated for the management of DOE's inventory of depleted UF_6 cylinders currently located at three storage sites. The alternative management strategies (also termed "alternatives") considered in this PEIS are no action (continuation of DOE's current management practices for depleted UF_6), long-term storage as UF_6, long-term storage as uranium oxide, use as uranium oxide, use as uranium metal, and disposal.

This chapter defines these alternatives in detail and discusses the types of activities that would be required under each, including descriptions of the representative facility designs and processing technologies considered. Alternatives (other than no action) are defined broadly to account for variations in the chemical form of uranium, technology choices, and facility design options that could be selected. A summary comparison of the potential environmental impacts of the alternatives is provided in Section 2.4, based on the environmental setting information in Chapter 3 and the detailed assessment results presented in Chapter 5 and Chapter 6.

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The preferred alternative would allow beneficial use of the material with regard to environmental, economic, technical, and other factors. The identification of a preferred alternative does not represent a decision by DOE; rather, it reflects DOE's preference on the basis of existing information. Because the preferred

Alternative Management Strategies Considered in the PEIS*

No Action — Continued storage of depleted UF_6 cylinders indefinitely in yards at the Paducah, Portsmouth, and K-25 sites.

Long-Term Storage as UF_6 — Storage as UF_6 cylinders in yards, buildings, or a mine at a consolidated site.

Long-Term Storage as Uranium Oxide — Conversion of UF_6 to an oxide, either UO_2 or U_3O_8, followed by storage in buildings, belowground vaults, or a mine at a consolidated site.

Use as Uranium Oxide — Conversion of UF_6 to an oxide, followed by the manufacture of oxide-shielded spent nuclear fuel or high-level waste storage containers (casks).

Use as Uranium Metal — Conversion of UF_6 to uranium metal, followed by the manufacture of metal-shielded spent nuclear fuel or high-level waste storage containers (casks).

Disposal — Conversion of UF_6 to an oxide, either UO_2 or U_3O_8, followed by disposal as low-level waste in shallow earthen structures, belowground vaults, or a mine.

*DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.

alternative combines aspects of several of the PEIS alternatives, it is discussed in detail separately in Section 2.5.

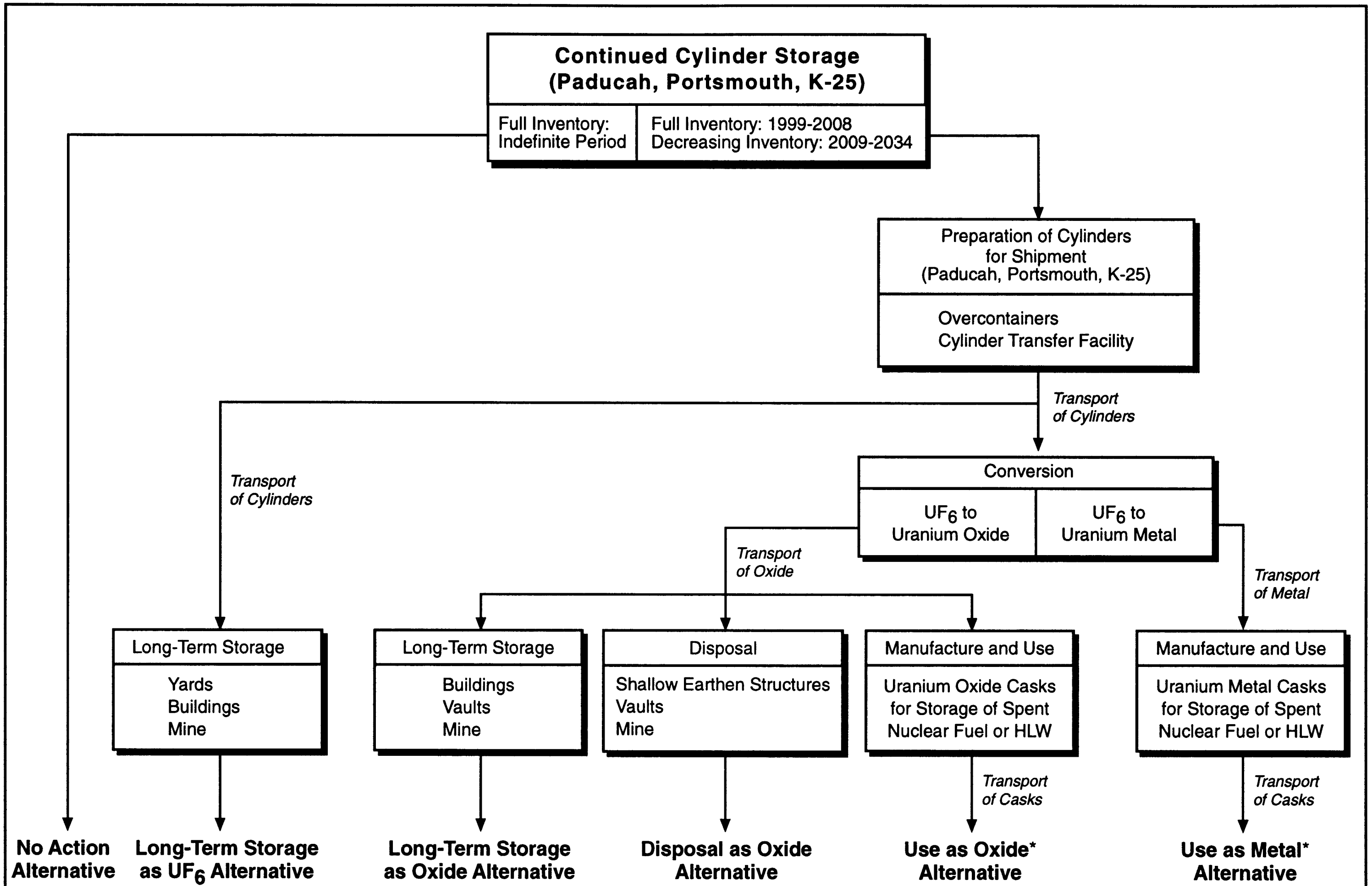
2.1 DEVELOPMENT OF ALTERNATIVE MANAGEMENT STRATEGIES

The alternative management strategies evaluated in detail in this PEIS were developed by considering that there are two possible permanent dispositions for depleted uranium, use or disposal, or the material could be kept in long-term storage. Each of these three options — use, disposal, or long-term storage — could potentially require a chemical form of uranium other than UF_6. Consequently, chemical form was also considered in defining the alternative strategies. These considerations resulted in the definition of alternatives that cover a range of reasonable management strategies, including the no action alternative.

The alternative management strategies were developed and announced in the Notice of Intent to prepare the PEIS, published in the *Federal Register* on January 25, 1996 (61 FR 2239). At the time of the Notice of Intent and public scoping, the no action alternative was based on the course of action outlined by Sewell (1992) (see Section 1.1). This course of action included eventual chemical conversion of UF_6 to uranium oxide followed by storage. After public scoping and on the basis of internal DOE reviews, it was determined that the no action alternative should consider the continued storage of UF_6 cylinders indefinitely at the three current storage sites.

Each alternative evaluated in the PEIS involves a series of management steps or activities that would take place over a number of years. The activities assumed to be required for each alternative are shown in Figure 2.1. For analysis purposes, the types of management activities were grouped into seven broad categories: continued cylinder storage at the current sites, cylinder preparation for shipment, conversion, long-term storage, manufacture and use, disposal, and transportation (see Section 1.5.2). To analyze potential impacts of these activities, several representative options, which are different ways that each activity could be accomplished, were considered for most activities (Figure 2.1). The PEIS will be used to select a broad management strategy on the basis of these representative options; specific facility designs, technologies, and processes will be evaluated following the Record of Decision for this PEIS in the Phase II studies and NEPA reviews.

The representative options were defined by technical experts on the basis of suggestions from the general public. DOE solicited suggestions from the public regarding potential uses or technologies that would facilitate management of depleted UF_6 in "Management of Depleted Uranium Hexafluoride: Request for Recommendations" published in the *Federal Register* in November 1994 (59 FR 56324). The responses to this request, together with DOE's preliminary list of options, were reviewed by technical experts. The results of this evaluation are summarized in the *Technology Assessment Report* (LLNL 1995). This report forms the basis for defining the representative options assessed in this PEIS. Descriptions of the representative options evaluated for each of the seven activity categories are given in Appendices D through J. Each appendix summarizes the different options considered for a specific type of activity and discusses the potential environmental impacts estimated for each option.



*DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Use as storage casks is a representative use for the purpose of analysis in this PEIS and does not preclude other uses.

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FIGURE 2.1 Major Components of the Alternative Management Strategies

The approach used to analyze the environmental impacts of each alternative was to evaluate the impacts of each individual activity required by the alternative and then combine them, as appropriate, to arrive at the total impacts. For example, the impacts of disposal would include impacts during continued storage of cylinders for some period, preparation of cylinders for shipment, transport of cylinders, conversion, treatment of empty cylinders, and disposal. In cases where more than one option was available to accomplish a single activity — such as disposal in shallow earthen structures, vaults, or a mine — the impacts of the alternative are presented as a range encompassing all the relevant options. For activities known to occur at the three current storage sites, the impacts were evaluated using environmental setting data for the actual site. For activities for which the locations will be decided in the future during Phase II of the Depleted Uranium Hexafluoride Management Program, impacts were evaluated by using representative or generic environmental settings (see Sections 3.4 and 4.2).

For assessment purposes, the environmental impacts of the alternative management strategies were evaluated and compared for the period 1999 through 2039 (41 years): about 10 years for siting, design, and construction of required facilities; about 26 years for operations; and, when appropriate, 4 years for monitoring.[1] In addition, long-term impacts (primarily from potential groundwater contamination) were estimated for the continued storage component of all alternatives and for the disposal alternative. Because actions to be taken beyond 2039 are considered highly uncertain and speculative, no assumptions were made regarding management beyond 2039. Actions beyond that date would be subject to appropriate NEPA reviews and decisions in the future. However, issues associated with potential life-cycle impacts are summarized in Section 2.6 and discussed in more detail in Section 5.9 of this PEIS.

For alternatives other than no action, to provide a basis for impact calculations, schedules for facility construction and operations were determined on the basis of engineering judgment (LLNL 1997a) and were used consistently. Schedules were not differentiated for DOE or private facilities. For the treatment of DOE-generated cylinders, it was generally assumed in the engineering analysis report that new facilities — such as those for conversion, manufacturing, long-term storage, and disposal — would begin operations by 2009 and continue for a period of 20 years.[1] To account for the processing of up to 15,000 USEC-generated cylinders, processing was assumed to be extended an additional 6 years, resulting in an overall operational period of 26 years. Following the Record of Decision, activities such as technology selection, facility design, site selection and preparation, facility construction, procurement, and appropriate safety and NEPA analyses would be required prior to facility start-up. Although the actual schedule for implementation of a selected alternative might differ from that assumed for the PEIS analyses, the impact estimates and conclusions reached in the PEIS would remain essentially the same.

Finally, to provide a conservative estimate of potential impacts, it was assumed for the PEIS that new facilities would be constructed for conversion, consolidated long-term storage,

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[1] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

manufacturing, and disposal, as required by the alternatives. To provide a conservative estimate of transportation and construction impacts, it was also assumed that these facilities would be located at separate sites, requiring transportation between them. The actual facilities, technologies, and sites that would be used will be evaluated in the Phase II studies and NEPA reviews after a management strategy is selected in the Record of Decision for this PEIS.

2.2 ALTERNATIVE MANAGEMENT STRATEGIES

2.2.1 No Action Alternative

Under the no action alternative, depleted UF_6 cylinder storage was assumed to continue at each of the three current storage sites indefinitely. Potential environmental impacts were estimated through the year 2039. In addition, long-term impacts (i.e., occurring after 2039) from potential groundwater contamination were assessed.

No Action Alternative

Continued storage of the UF_6 cylinders indefinitely at the Paducah, Portsmouth, and K-25 sites.

The environmental impacts of the no action alternative depend on the cylinder management activities that would take place at the sites in the future. Current detailed cylinder management plans extend through the year 2002 (LMES 1997i). The ongoing and planned activities are designed to ensure continued safe storage of cylinders. These activities include cylinder inspections, cylinder yard upgrades, cylinder painting, and cylinder maintenance and repair. Beyond 2002, a set of assumptions about future cylinder management was needed to define the activities that would likely occur at the sites through 2039 so that the potential impacts could be estimated. It was assumed that the types of activities occurring beyond 2002 would be similar to those that are now ongoing or planned (Parks 1997).

Specifically, the activities assumed to occur at the sites under the no action alternative include a comprehensive cylinder monitoring and maintenance program, with routine cylinder inspections, ultrasonic testing of cylinder wall thicknesses, radiological surveys, cylinder painting to prevent corrosion, cylinder yard surveillance and maintenance, construction of new or improved storage yards, and relocation of some cylinders to the new or improved yards. Cylinders were assumed to be painted every 10 years, which is consistent with current plans. These activities are described in greater detail in Appendix D.

The occurrence of future cylinder breaches, caused by either corrosion or handling damage, is an important concern when the potential impacts of continued cylinder storage are evaluated. For the assessment of the no action alternative, it was assumed that the current cylinder maintenance and painting program would maintain the cylinders in protected condition and control further corrosion

(Pawel 1997). After the initial painting, some cylinder breaches were assumed to occur in the future from handling damage. Although unlikely, for analytical purposes the cylinder breaches were assumed to go undetected for 4 years (the inspection interval for most cylinders) and to release some uranium and HF to the environment. Details concerning the current understanding of cylinder corrosion and the assumptions made for the purposes of this PEIS are provided in Appendix B.

Because the effectiveness of painting in controlling cylinder corrosion and the future painting schedule are somewhat uncertain, an assessment was also conducted on the basis of the assumption that external corrosion would not be halted by improved storage conditions, cylinder maintenance, and painting. Estimates were made of the time frames over which continued storage of cylinders would begin to raise regulatory concerns if corrosion rates were to continue at the historical rate (poor storage yard conditions and no routine cylinder painting).

2.2.2 Long-Term Storage as Depleted UF_6

In contrast to the no action alternative, the long-term storage as depleted UF_6 alternative was based on the assumption that storage would be consolidated at a single location and could involve storage of cylinders in newly constructed yards, buildings, or an underground mine. The location of such a long-term storage facility could be elsewhere than at a current storage site. To estimate potential environmental impacts, the alternative was assumed to consist of the following activities:

- Continued storage of UF_6 cylinders at the three current storage sites (existing cylinder management of the entire cylinder inventory through 2008 and of a decreasing inventory through 2034);
- Cylinder preparation for shipment at the three current storage sites (transfer to new cylinders or placement of cylinders in overcontainers);
- Transportation of cylinders to a long-term storage facility by truck or rail;
- Construction and operation of a long-term cylinder storage facility, including yards, buildings, or an underground mine; and
- Transportation and disposal of any waste created from the activities listed above.

Figure 2.2 shows each of the activities assumed to occur under the long-term storage as UF_6 alternative and their relationship to one another. The entire cylinder inventory was assumed to be stored at the three current storage sites

> **Long-Term Storage as UF_6 Alternative**
>
> Storage of UF_6 cylinders in newly constructed yards, buildings, or a mine at a consolidated site.

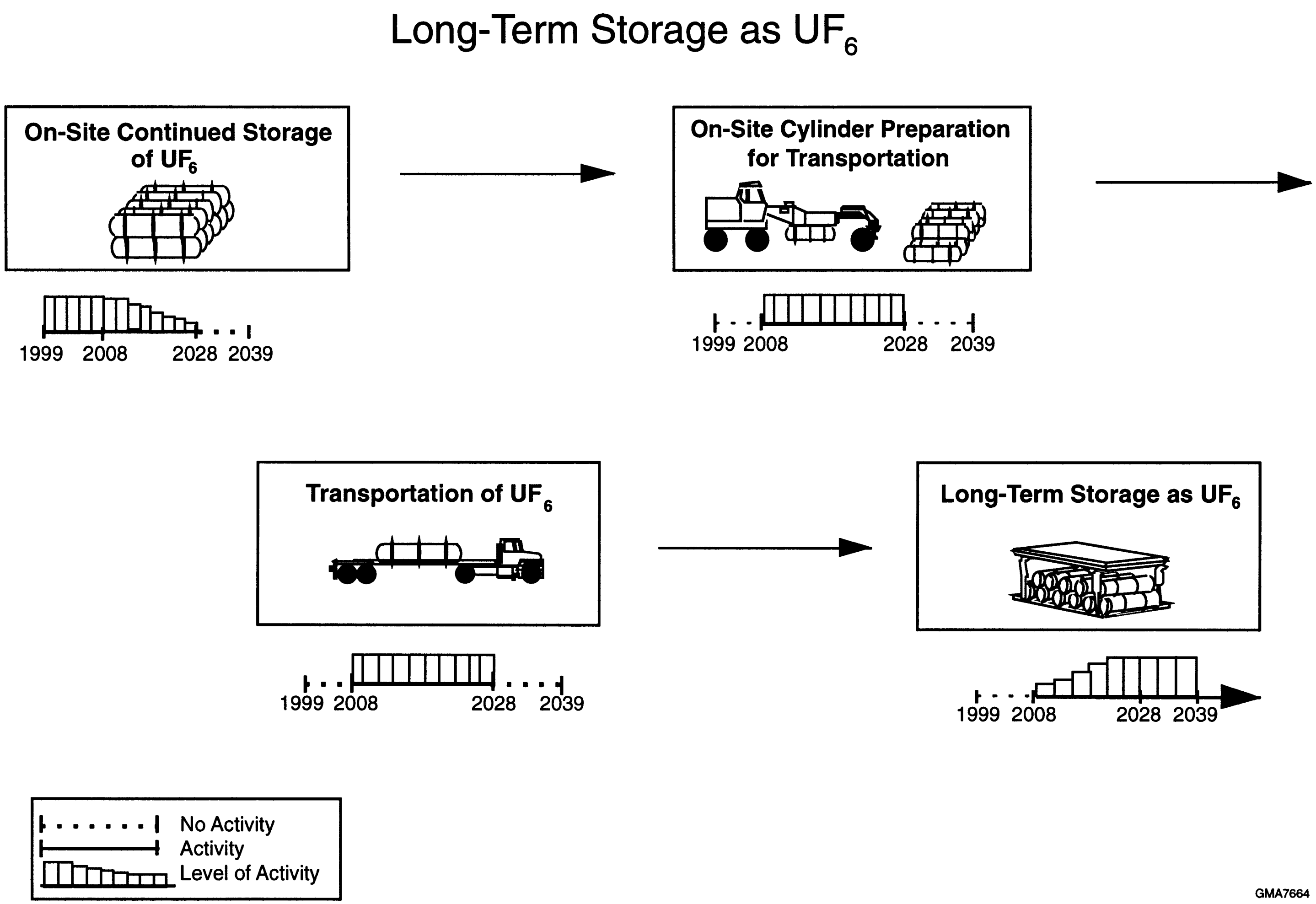

FIGURE 2.2 Conceptual Schematic of the Long-Term Storage as UF_6 Alternative (The management of an additional 15,000 USEC-generated cylinders would extend continued storage, cylinder preparation, and transportation activities through 2034. Note that the timetable presented was meant to provide a consistent analytical basis for the evaluation of all of the PEIS alternatives and does not represent a definitive schedule.)

through 2008, with the site inventory decreasing from 2009 through 2034 as cylinders were shipped off-site to a consolidated storage facility. The activities assumed to occur at the current storage sites during this time would include a comprehensive cylinder monitoring and maintenance program, including routine inspections and cylinder painting to control corrosion, and the construction and relocation of cylinders to new or improved cylinder yards. These activities are generally similar to those described for the no action alternative, although slight variations in maintenance and painting schedules were made to account for the decreasing cylinder inventory. Continued cylinder storage activities for this alternative are discussed in more detail in Appendix D.

Although the locations of facilities will be evaluated in Phase II studies and NEPA reviews, to provide a conservative estimate of potential transportation impacts, all cylinders were assumed to be transported from the three current storage sites to a consolidated long-term storage facility. Truck and rail shipment modes were considered as two representative transportation options, as described in detail in Appendix J.

Preparing the cylinders for off-site transportation was assumed to occur at the three current storage sites. Some cylinders might not be suitable for off-site transportation because they might not meet DOT requirements (see Appendix E). These cylinders would thus require some type of preparation prior to off-site shipment. Two cylinder preparation options were considered for these cylinders: (1) a cylinder overcontainer option, in which cylinders not meeting transportation requirements would be placed into a larger container approved for transportation, and (2) a cylinder transfer option, in which the contents of cylinders not suitable for transportation would be transferred to new cylinders. The cylinder overcontainer option would not require the construction of new facilities at the current sites; for the cylinder transfer option it was assumed that a transfer facility would be constructed at each site.

The three long-term storage options evaluated were storage in yards, buildings, and an underground mine. Descriptions of these representative long-term storage facilities are provided in Appendix G. All storage facilities were assumed to be newly constructed, stand-alone, single-purpose facilities consisting of a central receiving building/warehouse surrounded by storage areas, all within a security fence. Once placed in storage, the cylinders would be subject to routine monitoring and maintenance activities. The storage facilities would be designed to protect the cylinders from the environment and prevent potential releases of material to the environment.

2.2.3 Long-Term Storage as Uranium Oxide

Under the long-term storage as uranium oxide alternative, depleted UF_6 would be chemically converted from UF_6 to uranium oxide before placement in long-term storage. Storage in a retrievable form in a facility designed for indefinite, low-maintenance operation would preserve access to the depleted uranium. Storage in the form of an

Long-Term Storage as Uranium Oxide Alternative

Conversion of UF_6 to uranium oxide, either UO_2 or U_3O_8, followed by storage of drums of oxide in buildings, vaults, or a mine at a consolidated site.

oxide would be attractive in view of long-term stability and might be the form of material preferred for use or disposal at a later date.

Conversion of depleted UF_6 to an oxide was assumed to take place at a newly constructed, stand-alone plant dedicated to the conversion process. Two forms of uranium oxide, U_3O_8 and UO_2, were considered. Both oxide forms have low solubility in water and are relatively stable over a wide range of environmental conditions (see Appendix A). Two representative conversion technologies were assessed for conversion to U_3O_8 and three for conversion to UO_2. A detailed discussion of the conversion options is presented in Appendix F. Conversion options and other chemical forms for storage that were considered but not analyzed in detail are discussed in Section 2.3.

In addition to producing uranium oxide, conversion could result in the production of considerable quantities of HF. Anhydrous HF, a chemical that is toxic to humans if exposed to high-enough concentrations, is a commercially valuable chemical commonly used for industrial applications, including use for the production of UF_6 from natural uranium ore. HF is typically stored and transported as a liquid, and that produced from the conversion process could potentially be sold for use. Alternatively, the HF could be neutralized by the addition of lime to form a solid fluoride salt, calcium fluoride (CaF_2), which is much less toxic than HF. The CaF_2, a solid material, potentially could be sold for commercial use or could be disposed of in either a landfill or LLW disposal facility, depending on the uranium concentration and applicable disposal regulations at the time of disposal. Use of HF and CaF_2 would be subject to DOE or NRC review and approval, depending on the specific use. The environmental impacts of both options (production of anhydrous HF for commercial use and neutralization of HF to CaF_2) were considered in this PEIS.

Following conversion, the uranium oxide was assumed to be stored in drums in buildings, belowground vaults, or an underground mine. The storage facilities would be designed to protect the stored material from the environment and prevent potential releases of material to the environment. Once placed in storage, the containers would require only routine monitoring and maintenance activities. Additional details related to long-term storage options are provided in Appendix G.

Figure 2.3 depicts the activities assumed to occur under the long-term storage as uranium oxide alternative, including the following:

- Continued storage of UF_6 cylinders at the current storage sites (existing cylinder management of the entire cylinder inventory through 2008 and of a decreasing inventory through 2034);

- Cylinder preparation for shipment at the three current storage sites (transfer to new cylinders or placement of cylinders in overcontainers);

- Transportation of depleted UF_6 to a conversion facility by truck or rail;

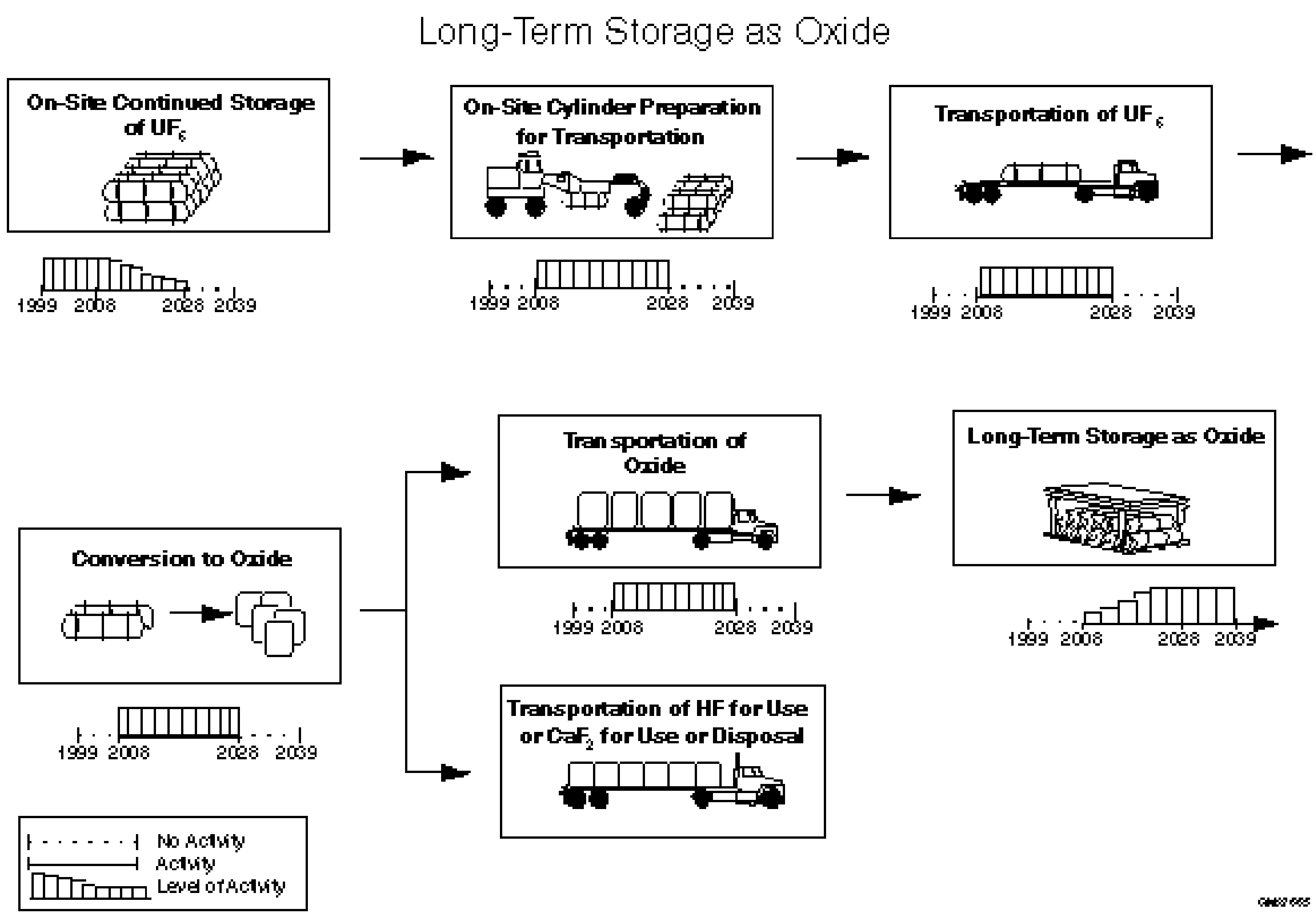

FIGURE 2.3 Conceptual Schematic of the Long-Term Storage as Oxide Alternative (The management of an additional 15,000 USEC-generated cylinders would extend continued storage, cylinder preparation, conversion, and transportation activities through 2034. Note that the timetable presented was meant to provide a consistent analytical basis for the evaluation of all of the PEIS alternatives and does not represent a definitive schedule.)

- Construction and operation of a conversion facility, and conversion to either U_3O_8 or UO_2;
- Transportation of the uranium oxide to a long-term storage facility by truck or rail;
- Transportation of either HF for use or CaF_2 for use or disposal;
- Construction and operation of a long-term storage facility, including buildings, belowground vaults, or an underground mine; and
- Transportation and disposal of any waste created from the activities listed above.

Storage of the entire cylinder inventory at the three current storage sites was assumed to continue through 2008. Beginning in 2009, and continuing for up to 26 years (when USEC-generated cylinders are considered), cylinders would be prepared for transportation and transported to a conversion facility. Cylinders would be subject to the same monitoring and maintenance practices as described for the long-term storage as depleted UF_6 alternative. The depleted UF_6 would be converted to oxide from 2009 through 2034, and the oxide would be transported to a long-term storage facility.[2] If HF were produced, it was assumed to be transported elsewhere for use. If a fluoride salt were produced, it was assumed to be transported for use or disposal. Following placement of the last container of oxide in the long-term storage facility, monitoring would continue indefinitely. However, for purposes of analysis and comparison with other alternatives, only the period through 2039 was evaluated. Although facility locations will be evaluated in Phase II studies and NEPA reviews, the conversion and long-term storage facilities were assumed to be located at locations other than the three current cylinder storage sites to provide a conservative estimate of potential transportation impacts.

2.2.4 Use as Uranium Oxide

Under the use as uranium oxide alternative, depleted UF_6 would first be chemically converted to uranium oxide. There are a variety of current and potential uses for depleted uranium, including use as radiation shielding, use in dense material applications other than shielding (such as ballast or tank armor), use in light water reactor fuel cycles, and use in advanced reactor fuel cycles. Radiation shielding was selected as the representative use option for detailed analysis in the PEIS (potential uses not considered in detail are discussed in Section 2.3.2). Use as shielding was selected to provide a basis for comparing the broad programmatic management strategies. This selection was not intended to imply that the PEIS will be used to select a specific end use or preclude other uses

[2] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

in the future. Specific issues, such as licensing, associated with potential uses would be considered and evaluated in more detail in future planning and environmental analyses once a management strategy is selected.

Use as Uranium Oxide Alternative

Conversion of UF_6 to an oxide, followed by the manufacture of oxide-shielded casks for use as spent nuclear fuel or HLW storage containers.

For assessment purposes, it was assumed that depleted UF_6 would be converted to UO_2, which in turn would be used to make the primary shielding material in casks designed to contain spent nuclear fuel or high-level radioactive waste (HLW).[3] The high density of uranium makes it an excellent radiation shield for gamma radiation. (Shielding is any material that is placed between a source of radiation and people, equipment, or other objects to absorb the radiation and thereby reduce radiation exposure.) If UO_2 was used to make concrete (called depleted-uranium-concrete), the same shielding performance could be achieved with approximately half the thickness required of normal concrete. The uranium oxide would be substituted for the coarse aggregate in conventional concrete and would be enclosed between the stainless steel shells making up the body of the casks. Additional details concerning the representative use option are provided in Appendix H.

A conversion facility would be required to convert UF_6 to oxide, similar to that described for the long-term storage as oxide alternative (see also Appendix F). The stand-alone facility would convert UF_6 to UO_2 and would also produce either anhydrous HF or CaF_2. If HF were produced, it was assumed to be transported elsewhere for use; if CaF_2 were produced, it was assumed to be transported for either use or disposal.

The manufacture of depleted-uranium-shielded casks was assumed to take place at a stand-alone industrial plant dedicated to the cask manufacturing process (see Appendix H). The plant would be capable of receiving packages of UO_2 on trucks or railcars from a conversion facility, manufacturing casks, and storing the casks until shipment by rail to a user, such as a nuclear power plant or DOE facility.

Figure 2.4 depicts the activities assumed to occur under the use as uranium oxide alternative, including the following:

- Continued storage of UF_6 cylinders at the current storage sites (existing cylinder management of the entire cylinder inventory through 2008 and of a decreasing inventory through 2034);

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3 Such casks are typically used for purposes of storage or transportation (or both) of spent nuclear fuel and high-level waste; certification generally would be required from the U.S. Nuclear Regulatory Commission prior to use, pursuant to 10 CFR Parts 71 and 72.

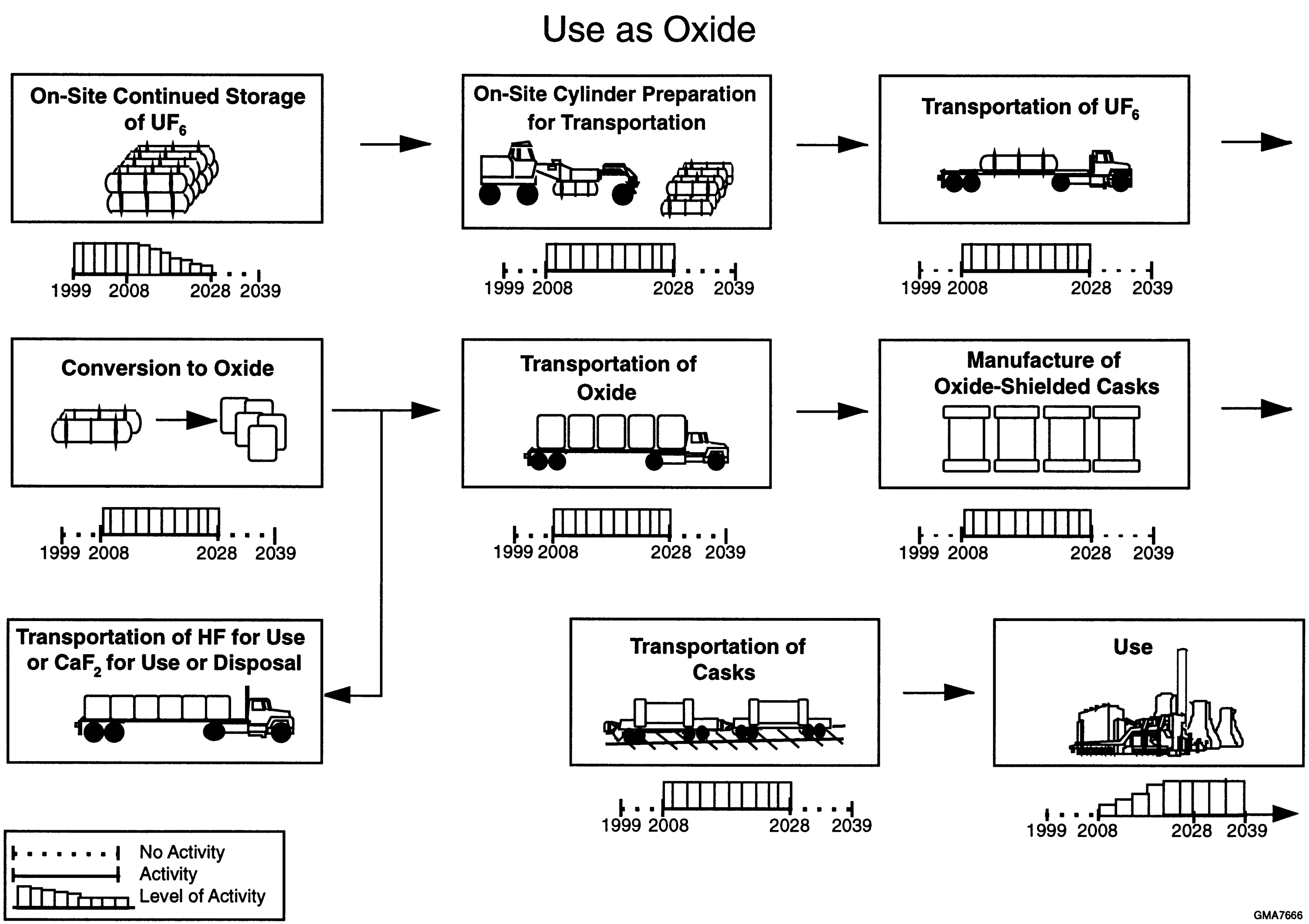

FIGURE 2.4 Conceptual Schematic of the Use as Oxide Alternative (The management of an additional 15,000 USEC-generated cylinders would extend continued storage, cylinder preparation, conversion, manufacturing, and transportation activities through 2034. Note that the timetable presented was meant to provide a consistent analytical basis for the evaluation of all of the PEIS alternatives and does not represent a definitive schedule.)

- Cylinder preparation for shipment at the three current storage sites (transfer to new cylinders or placement of cylinders in overcontainers);

- Transportation of depleted UF_6 to a conversion facility by truck or rail;

- Construction and operation of a conversion facility, and conversion to UO_2;

- Transportation of the UO_2 to a cask manufacturing facility by truck or rail;

- Transportation of either HF for use or CaF_2 for use or disposal;

- Construction and operation of a cask manufacturing facility, and manufacture of depleted-uranium-concrete casks;

- Transportation of depleted-uranium-concrete casks to a user by rail; and

- Transportation and disposal of any waste created from the activities listed above.

Storage of the entire cylinder inventory at the three current storage sites was assumed to continue through 2008. Beginning in 2009, and continuing for up to 26 years, cylinders would be prepared for transportation and transported to a conversion facility. Cylinders would be subject to the same monitoring and maintenance practices as described for the long-term storage as depleted UF_6 alternative. The depleted UF_6 would be converted to UO_2 from 2009 through 2034, and the UO_2 would be transported to a facility that manufactures depleted-uranium-concrete casks.[4] Manufacture and use of the casks would take place between 2009 and 2034. It was assumed that casks would be in use at user facilities through at least 2039. Although facility locations will be evaluated in Phase II studies and NEPA reviews, the facilities for conversion, manufacturing, and use were assumed to be at locations other than the three current cylinder storage sites to provide a conservative estimate of potential transportation impacts.

Because actions beyond 2039 are considered highly uncertain and speculative, no assumptions were made regarding the fate of depleted-uranium-concrete casks following use. However, issues related to potential life-cycle impacts are summarized in Section 2.6 and discussed in more detail in Section 5.9.

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[4] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

2.2.5 Use as Uranium Metal

Use as Uranium Metal Alternative

Conversion of UF_6 to uranium metal, followed by the manufacture of metal-shielded casks for use as spent nuclear fuel or HLW storage containers.

Under the use as uranium metal alternative, depleted UF_6 would first be chemically converted to uranium metal. As discussed for the use as oxide alternative, there are a variety of current and potential uses for depleted uranium. As a representative use for the PEIS analysis, uranium metal was assumed to be used as the primary shielding material in casks designed to contain spent nuclear fuel or HLW (see footnote 1). (Several other uses considered but not analyzed in detail are discussed in Section 2.3.2.) The uranium metal would be enclosed between the stainless steel shells making up the body of the casks. Additional details concerning the representative use option are provided in Appendix H.

A conversion facility would be required to convert UF_6 to uranium metal (see Appendix F). The conversion facility would also produce either anhydrous HF or CaF_2. If HF were produced, it was assumed to be transported elsewhere for use; if a fluoride salt were produced, it was assumed to be transported for either use or disposal. As described in Appendix F, metal conversion technologies would also produce large quantities of magnesium fluoride (MgF_2). The MgF_2 would be disposed of in either a sanitary landfill or LLW disposal facility, depending on the uranium concentration and applicable disposal regulations at the time of disposal.

The manufacture of depleted-uranium-metal casks was assumed to take place at a stand-alone industrial plant dedicated to the cask manufacturing process (see Appendix H). The plant would be capable of receiving uranium metal from a conversion facility, manufacturing casks, and storing the casks until shipment by rail to a user, such as a nuclear power plant or DOE facility.

The activities required for the use as uranium metal alternative would be the same as those for the use as uranium oxide alternative, except that the UF_6 would be converted to metal instead of oxide. Figure 2.5 depicts the activities assumed to occur under the use as uranium metal alternative, including the following:

- Continued storage of UF_6 cylinders at the current storage sites (existing cylinder management of the entire cylinder inventory through 2008 and of a decreasing inventory through 2034);

- Cylinder preparation for shipment at the three current storage sites (transfer to new cylinders or placement of cylinders in overcontainers);

- Transportation of depleted UF_6 to a conversion facility by truck or rail;

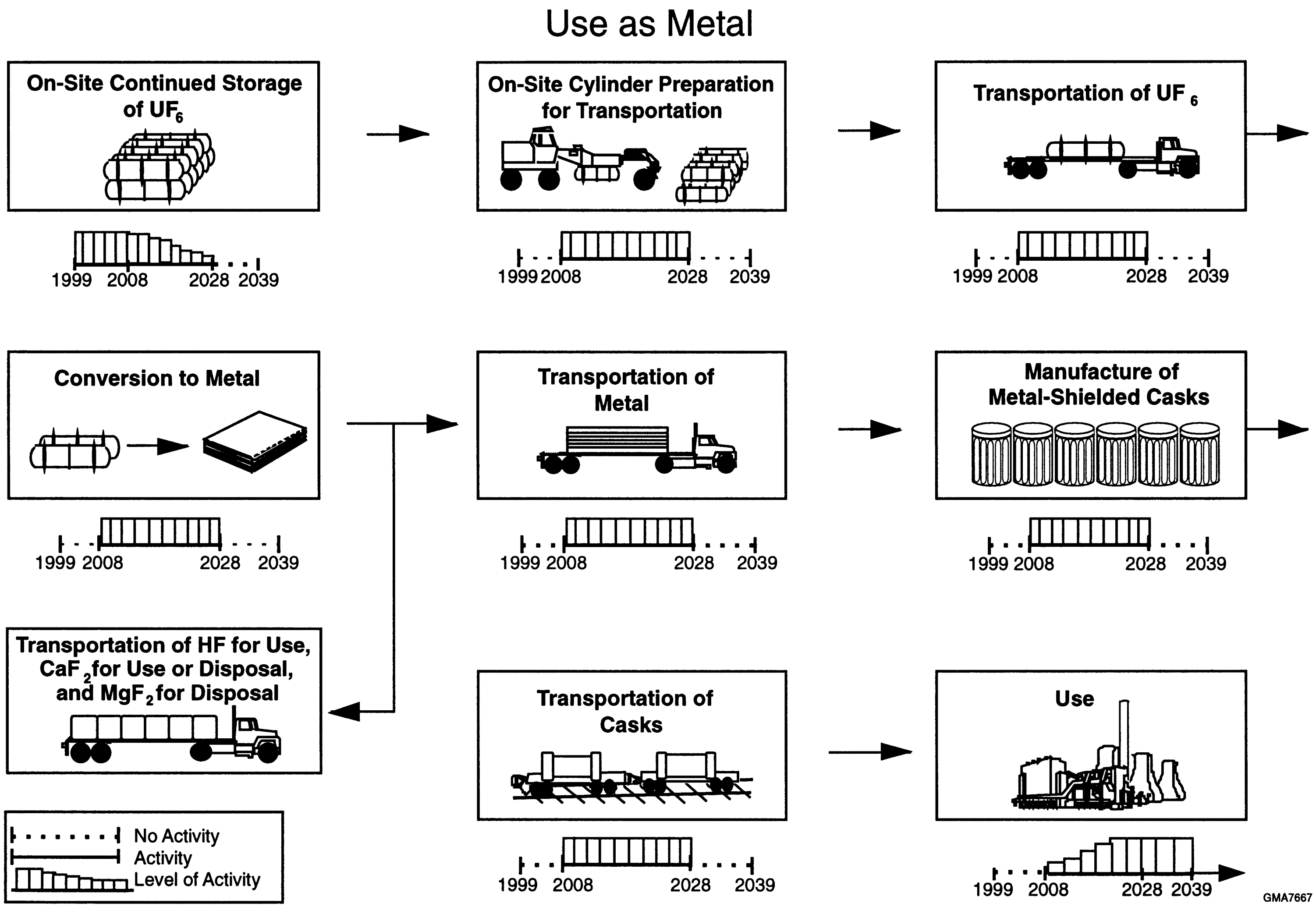

FIGURE 2.5 Conceptual Schematic of the Use as Metal Alternative (The management of an additional 15,000 USEC-generated cylinders would extend continued storage, cylinder preparation, conversion, manufacturing, and transportation activities through 2034. Note that the timetable presented was meant to provide a consistent analytical basis for the evaluation of all of the PEIS alternatives and does not represent a definitive schedule.)

- Construction and operation of a conversion facility, and conversion to uranium metal;

- Transportation of the uranium metal to a cask manufacturing facility by truck or rail;

- Transportation of either HF for use or CaF_2 for use or disposal, and MgF_2 for disposal;

- Construction and operation of a cask manufacturing facility, and manufacture of depleted-uranium-metal casks;

- Transportation of depleted-uranium-metal casks to a user by rail; and

- Transportation and disposal of any waste created from the activities listed above.

The assumptions for the use as uranium metal alternative are the same as those discussed in Section 2.2.4 for the use as uranium oxide alternative. No assumptions were made regarding the fate of casks after use; however, issues related to potential life-cycle impacts are summarized in Section 2.6 and discussed in more detail in Section 5.9.

2.2.6 Disposal

Under the disposal as uranium oxide alternative, depleted UF_6 would be chemically converted to a more stable oxide form and disposed of belowground as LLW. Disposal is defined as the emplacement of material in a manner designed to ensure isolation for the foreseeable future. Compared with long-term storage, disposal is considered to be permanent, with no intent to retrieve the material for future use. In fact, considerable and deliberate effort would be required to regain access to the material following disposal.

Disposal as Oxide Alternative

Conversion of UF_6 to uranium oxide, either UO_2 or U_3O_8, followed by disposal as low-level waste in shallow earthen structures, belowground vaults, or a mine.

Prior to disposal, conversion of depleted UF_6 to an oxide was assumed to take place at a newly constructed, stand-alone plant dedicated to the conversion process (see Appendix F). This activity would be identical to that described in Section 2.2.3 for long-term storage as oxide. Potential impacts were evaluated for U_3O_8 and UO_2, which both have low solubility in water and are relatively stable over a wide range of environmental conditions. The conversion facility would convert UF_6 to oxide and would also produce either anhydrous HF or CaF_2. If HF were produced, it was assumed to be transported elsewhere for use; if a fluoride salt were produced, it was assumed to be transported for either use or disposal.

Several disposal options were considered, including disposal in shallow earthen structures, belowground vaults, and an underground mine (see Appendix I). In addition, two physical waste forms were considered in the PEIS, ungrouted waste and grouted waste. Ungrouted waste refers to U_3O_8 or UO_2 in the powder or pellet form produced during the conversion process. This bulk material would be disposed of in drums. Grouted waste refers to the solid material obtained by mixing the uranium oxide with cement and repackaging it in drums. Grouting is intended to increase structural strength and stability of the waste and to reduce the solubility of the waste in water. However, because cement would be added to the uranium oxide, grouting would increase the total volume requiring disposal. Grouting of waste was assumed to occur at the disposal facility. Disposal options considered but not analyzed in detail are discussed in Section 2.3.4.

Figure 2.6 depicts the activities assumed to occur under the disposal as oxide alternative, including the following:

- Continued storage of UF_6 cylinders at the current storage sites (existing cylinder management of the entire cylinder inventory through 2008 and of a decreasing inventory through 2034);

- Cylinder preparation for shipment at the three current storage sites (transfer to new cylinders or placement of cylinders in overcontainers);

- Transportation of depleted UF_6 to a conversion facility by truck or rail;

- Construction and operation of a conversion facility, and conversion to either U_3O_8 or UO_2;

- Transportation of the uranium oxide to a disposal facility by truck or rail;

- Transportation of either HF for use or CaF_2 for use or disposal;

- Construction and operation of a disposal facility, including shallow earthen structures, belowground vaults, or an underground mine; and

- Transportation and disposal of any waste created from the activities listed above.

Storage of the entire cylinder inventory at the three current storage sites was assumed to continue through 2008. Beginning in 2009, and continuing for up to 26 years, cylinders would be prepared for transportation and transported to a conversion facility. Cylinders would be subject to the same monitoring and maintenance practices as described for the long-term storage as depleted

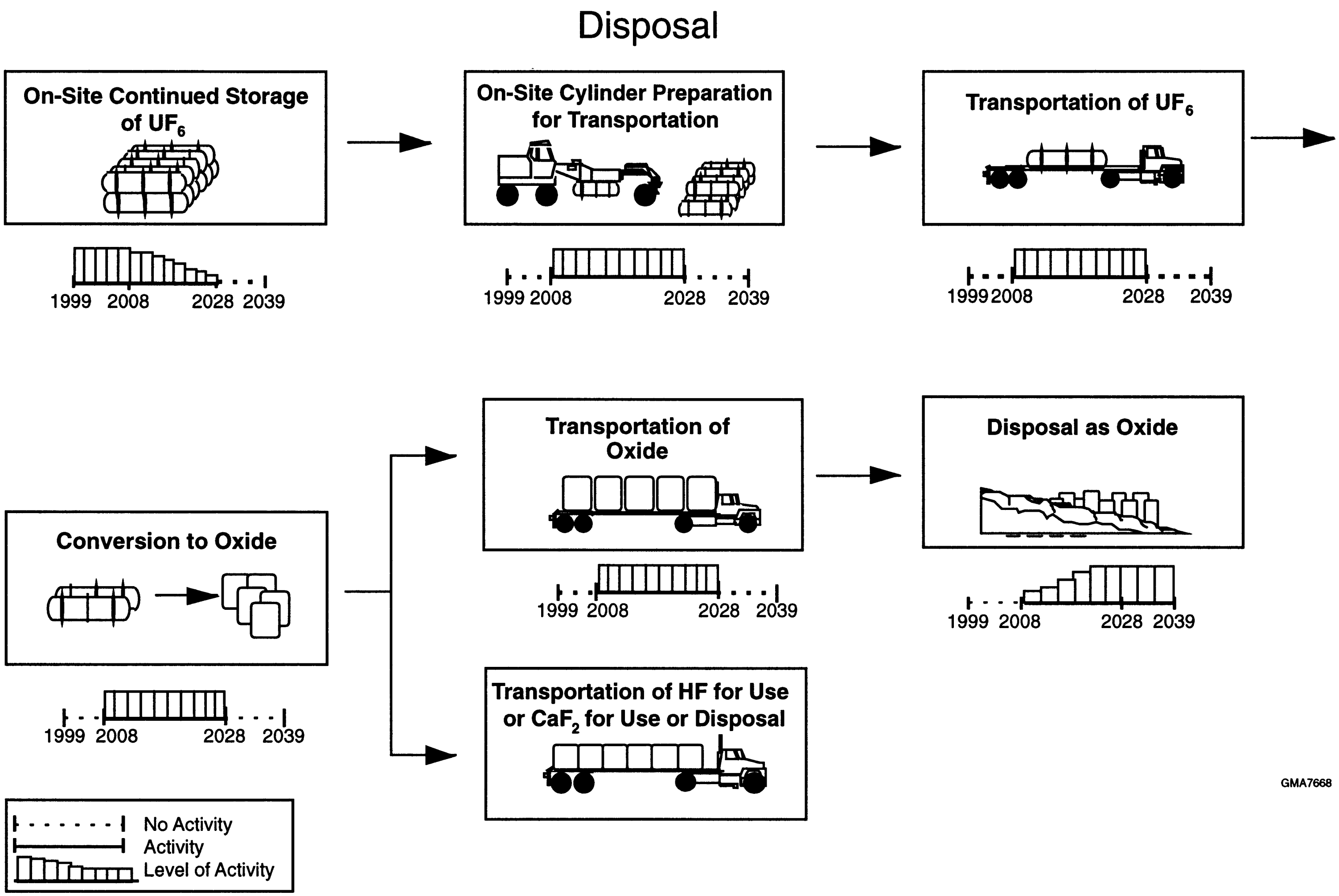

FIGURE 2.6 Conceptual Schematic of the Disposal as Oxide Alternative (The management of an additional 15,000 USEC-generated cylinders would extend continued storage, cylinder preparation, conversion, manufacturing, and transportation activities through 2034. Note that the timetable presented was meant to provide a consistent analytical basis for the evaluation of all of the PEIS alternatives and does not represent a definitive schedule.)

UF_6 alternative. The depleted UF_6 would be converted to oxide from 2009 through 2034, and the oxide would be transported to a disposal facility.[5] If HF were produced, it was assumed to be transported elsewhere for use; if a fluoride salt were produced, it was assumed to be transported for use or disposal. Although facility locations will be evaluated in Phase II studies and NEPA reviews, the conversion and disposal facilities were assumed to be at locations other than the three current cylinder storage sites to provide a conservative estimate of potential transportation impacts.

The potential impacts of disposal were evaluated for both the operational period of the facility (through 2039) and the long term because long-term impacts from disposal are reasonably foreseeable. Long-term impacts were estimated up to 1,000 years after the disposal facility had ceased operations. In addition, these impacts were estimated for both wet environmental settings (typical of the eastern United States) and dry environmental settings (typical of the western United States) (see Sections 3.4 and 4.2).

2.3 ALTERNATIVE MANAGEMENT STRATEGIES AND OPTIONS NOT ANALYZED IN DETAIL

This PEIS evaluates a range of reasonable management strategies based on representative facility, technology, and process options. During DOE's internal scoping and solicitation of recommendations, a number of promising technologies were recommended that were considered unsuitable for detailed analysis in this PEIS. With few exceptions, these technologies are in the early stages of either conceptualization or development, entail time frames beyond those included in the current analysis, or involve uses of insignificant amounts of depleted uranium. However, any technology that is not analyzed in depth in this PEIS may still be appropriate for consideration in the later Phase II studies and NEPA reviews that will provide a basis for selecting specific technologies and sites. A more detailed description of options considered but not analyzed in detail is presented in the engineering analysis report (LLNL 1997a).

2.3.1 Conversion

In response to the Request for Recommendations, many promising future conversion technologies were identified; however, with few exceptions, these technologies are now in the early stages of either conceptual development or design. In addition, key design aspects are proprietary for a number of these submittals. From an environmental perspective, these conversion processes would be generally similar to those included in the PEIS (see Appendix F); they all begin with processing major quantities of depleted UF_6 and end with a product containing fluorine. The impacts of conversion, including the chemical hazard of the fluorine in UF_6 and HF, are adequately addressed in the analysis of storage, handling, and transportation presented in the PEIS.

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[5] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

2.3.2 Use

Three options for use were not analyzed in depth: (1) light water reactor fuel cycles, (2) advanced reactor fuel cycles, and (3) dense material applications other than shielding.

Use of depleted uranium in the light water reactor fuel cycle would generally require reenrichment of depleted uranium (refeed), which could conserve natural uranium resources. However, the amount of energy required to obtain a unit quantity of enriched uranium from depleted uranium would be greater than the amount required if natural uranium feed were enriched using gaseous diffusion, which is currently the only available enrichment technology in the United States. Depending on the fuel mix (coal, nuclear, or hydro) used to generate the electricity for running the diffusion plant, the environmental emissions of air pollutants might also be greater under the refeed scenario than if natural uranium were used. In addition, the quantity of depleted UF_6 that would still require management after refeed would be essentially the same as it is now. If a more efficient enrichment technology — such as gas centrifugation or atomic vapor laser isotope separation — becomes commercially available in the future, using depleted UF_6 to make reactor fuel might also become more advantageous than using natural uranium. The long-term storage alternatives analyzed in the PEIS would preserve the option of the future development of a more efficient enrichment technology. The advantages and disadvantages of using depleted UF_6 for reenrichment are discussed further in White (1997) and Gillette (1997).

An additional potential use of depleted uranium in light water reactor fuel cycles could involve the conversion of UF_6 to UO_2, which could then be mixed with plutonium oxide to produce mixed oxide fuel or mixed with highly enriched uranium to produce commercial reactor fuel. These potential uses are being evaluated in the *Surplus Plutonium Disposition Draft Environmental Impact Statement* (DOE 1998a) and the *Disposition of Surplus Highly Enriched Uranium, Final Environmental Impact Statement* (DOE 1996a) (see Section 1.6); however, the amount of depleted uranium being considered for this type of application would be very small compared with the available inventory.

Use of depleted uranium in advanced reactor fuel cycles, most notably in a future generation of fast breeder reactors, was one of DOE's original reasons for continuing to store the material. In advanced reactor fuel cycles, the depleted uranium inventory could represent hundreds of years of electrical power at the current U.S. consumption rate. Implementation of an advanced reactor fuel cycle would require a change in national policy. The United States now uses a once-through fuel cycle derived from natural uranium. All existing fast breeder reactors use either highly enriched uranium, plutonium from recycling and reprocessing of spent nuclear fuel, or both. However, plutonium recycling and reprocessing are not currently practiced in the United States. The possibility of pursuing this option in the future would be retained under the long-term storage alternatives.

Dense material applications include existing uses of depleted uranium metal, such as armor-piercing munitions (penetrators), vehicle armor, and industrial ballasts. Potential new commercial applications that were identified in response to the Request for Recommendations are energy storage flywheels and drill collars, well penetrators, industrial counterweights, and shape charge perforators for the petroleum industry. Because the manufacturing processes associated with these applications would be similar for all dense material applications, the environmental impacts of new manufacturing facilities to accommodate expansion of existing uses or major new uses for dense materials would be similar to those for the representative facility assessed in the PEIS for the manufacture of uranium metal radiation shielding.

2.3.3 Long-Term Storage

Options for storage as elemental uranium metal and storage as uranium tetrafluoride (UF_4) were considered but not analyzed in depth. The chemical forms for storage analyzed in the PEIS (UF_6, U_3O_8, and UO_2) provide planning flexibility and allowed a spectrum of environmental and cost trade-offs to be considered. Storage of depleted uranium implies a significant chance that it will be used at a later date. The uranium chemical forms analyzed for storage encompass a range of important factors, including which future use options are considered most likely, storage space requirements, costs, potential environmental effects, and suitability of the chemical form for eventual disposal.

Green salt, or UF_4, is an intermediate form in the process of converting UF_6 to the metal form or converting uranium oxide to UF_6. Although UF_4 is more stable than UF_6, it has no identified direct use, offers no obvious advantage in required storage space, and is less stable than oxide forms. Conversion of UF_6 into uranium-bearing minerals such as soddyite and uranotile for subsequent storage or disposal were not analyzed because development of chemical conversion processes would be required, as well as examination of the suitability of such forms for storage or disposal.

Because of its high density, uranium metal would need less storage space than the other forms analyzed for storage. However, disadvantages include higher conversion cost, lower chemical stability than the oxides, and uncertainty about the suitability of the metal form for eventual disposal. Unless it is protected from the environment, bulk uranium metal slowly oxidizes. Metal fines or chips ignite spontaneously with a rapid energy release. Hydrogen is generated in the reaction between moisture and uranium metal, and care must be taken to avoid accumulation of hydrogen in closed storage containers. These safety issues would necessitate specialized packaging and enhanced facility maintenance. If the depleted UF_6 was converted to another chemical form for storage, it would be desirable for this form to be acceptable for disposal to avoid a later additional chemical conversion step. Consequently, long-term storage as metal was considered but not analyzed in detail in the PEIS.

2.3.4 Disposal

Options for disposal of depleted uranium as UF_6, as uranium metal, and as UF_4 were considered but not analyzed in detail. Factors that are important and were analyzed in determining the preferred chemical form for disposal of depleted uranium are potential for release, physical characteristics, and toxicity in drinking water. With regard to UF_6, because it is soluble in water and not as stable as other chemical forms, it was not considered suitable for disposal. To a lesser degree, UF_4 is also soluble in water and not as stable as oxide forms, and it was thus not analyzed.

This PEIS does not analyze disposal of uranium metal because it is reactive. Water attacks bulk uranium metal slowly at room temperature and rapidly at higher temperatures; UO_2 and U_3O_8 are formed, heat is generated, and the metal swells and disintegrates. Additionally, current DOE Orders restrict the disposal of uranium metal at DOE disposal sites, and no commercial disposal facilities are available for disposal of the inventory in the metal form (Hertzler et al. 1994). Relaxation of current waste acceptance criteria would likely be needed for disposal of metal to occur. Because of its higher conversion costs, reactivity, and the current regulatory restrictions, disposal as uranium metal was considered but not analyzed in detail in the PEIS.

Vitrification of depleted uranium oxides prior to disposal was another option considered. However, technologies for vitrification of depleted uranium oxides are in the early stages of development, and vitrification would likely increase the volume of the material by 100 to 400% compared with a 50 to 100% increase for grouting. Also, the capability of vitrification to reduce the already low leachability of uranium oxide compounds is unknown. For the purposes of the PEIS, grouted waste was considered representative of immobilized waste forms with low leach rates. The feasibility of vitrification of uranium oxides resulting from conversion of depleted UF_6 is further discussed in Swanstrom et al. (1997).

2.3.5 Transportation

Truck and rail were considered as representative transport modes for the shipment of materials. Transportation by barge was considered but not analyzed in detail because the locations of potential conversion, manufacturing, storage, or disposal facilities will be evaluated in Phase II studies and NEPA reviews, and accessibility to points of entry for barge transportation are uncertain. All three existing storage sites currently rely predominantly on ground transportation, and ground transportation would be necessary between the current storage locations and any barge facility and between the receiving barge facility and the disposal site. Barge transportation is a site-specific consideration that can be better analyzed in the later Phase II analyses supporting a facility siting decision.

2.3.6 Disposition of Empty Cylinders

Under most of the alternatives considered in this PEIS, the depleted UF_6 would be removed from some of the steel cylinders that are currently in use. The only exceptions would be the no action alternative and the long-term storage as UF_6 alternative, under which some or all of the cylinders might not need to be emptied until after 2039. Therefore, disposition of the empty cylinders would be part of most of the alternative management strategies. The treatment (i.e., cleaning and washing) of empty cylinders is considered in detail in this PEIS (see Appendix F). The disposition of clean, emptied cylinders is analyzed in detail in a PEIS support document (Nieves et al. 1997). This PEIS assumes that after treatment, the cylinders would become part of the DOE scrap metal inventory and managed as such.

The document by Nieves et al. (1997) analyzes the potential health and cost impacts associated with various options for the empty cylinders after treatment, including recycle into LLW disposal containers, reuse as LLW containers, free release for remelting, and disposal (i.e., burial) as LLW. Health endpoints assessed include chemical risks, radiation risks, and trauma risks. Total inventory health risks over 20 years of processing 46,422 cylinders ranged from 0.1 to 0.8 total fatality for the various options. The potential health impacts were similar for each of the options; however, the disposal option would have the greatest adverse environmental impacts because of the land allocations required and the removal of the metal mass from any further usefulness. The health impacts associated with the disposition of 61,422 cylinders (46,422 DOE-generated cylinders plus up to an additional 15,000 USEC-generated cylinders) over a 26-year period would be expected to be approximately 30% greater than for the DOE-generated cylinders alone.

2.3.7 Combinations of Alternatives

The alternatives assessed in this PEIS were based on the assumption that all facilities would be designed to either convert, store, manufacture and use, or dispose of all of the depleted UF_6 in the inventory. This approach was intended to provide an estimate of the maximum impacts that could result from each of the alternatives considered. However, as described for the preferred alternative in Section 2.5, it is possible for DOE to select a long-term management strategy that is a combination of the alternatives evaluated explicitly in the PEIS. For example, DOE could select a strategy to convert 50% of the depleted UF_6 to an oxide for use and convert the remaining 50% to metal for use. In this case, facilities could be designed to process or accommodate only a fraction of the depleted UF_6 inventory, and the resulting potential environmental impacts might be different than those evaluated for full-scale facilities. Consequently, the PEIS includes an analysis of potential environmental impacts for a range of facility sizes to allow for an evaluation of combinations of alternatives. The results of this “parametric” analysis are presented in Appendix K.

The intent of the parametric analysis was to show how the potential environmental impacts calculated for the full-scale facilities (i.e., 100% cases) would be affected by reductions in facility size and/or throughput. “Throughput” is a general term that refers to the amount of material handled or processed by a facility in 1 year. Appendix K presents the potential environmental impacts for the conversion, long-term storage, manufacture and use, disposal, and transportation options for facilities designed to process between 25 and 100% of the DOE-generated cylinder inventory. The parametric analysis would also allow for the evaluation of impacts associated with multiple facilities with fixed total throughput. (The impacts of the cylinder preparation options for various throughputs are not included in Appendix K but are addressed in Appendix E.) The basic assessment approach, areas of impact, and methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases.

2.4 COMPARISON OF ALTERNATIVES

The PEIS evaluates the potential environmental consequences of a range of alternatives, including no action. Table 2.1 presents a summary comparison of the management activities considered under the different alternatives. The preferred alternative, which is a combination of the alternatives discussed in this section, is discussed in Section 2.5. No alternative is unique in the activities required to accomplish it. A number of management activities are shared by two or more alternatives, as follows:

- Continued cylinder storage would continue at the three current storage sites under all alternatives. Under the no action alternative, continued cylinder storage was assumed to continue indefinitely. Under the other alternatives, cylinders were assumed to be removed from the sites over the period 2009 through 2034 for consolidated long-term storage or conversion.

- Preparation of cylinders for off-site transportation was considered at each of the three current storage sites for all alternatives other than no action.

- Conversion of UF_6 to another chemical form (oxide or metal) and treatment of the empty cylinders are activities considered under the long-term storage as oxide, use as uranium oxide, use as metal, and disposal alternatives (as well as the preferred alternative).

- Consolidated long-term storage is an activity in the long-term storage as UF_6 alternative and long-term storage as oxide alternative as well as the preferred alternative.

- Manufacture of radiation shielding (for use in casks for spent nuclear fuel or HLW) is an activity considered in the use as uranium oxide and use as uranium metal alternatives (as well as the preferred alternative).

Table 2.1 also contains a summary of the materials assumed to be transported between sites for each alternative. Because the locations of conversion, manufacture and use, long-term storage, and disposal sites will be decided in Phase II studies and NEPA reviews, it was assumed that these sites would be at separate locations, requiring transportation of materials between them. This approach was intended to provide a conservative estimate of potential transportation impacts.

The potential environmental impacts for the PEIS alternatives that are presented and compared in this section are taken from the more detailed environmental consequence assessments

TABLE 2.1 Comparison of Activities under the PEIS Alternatives (Note that DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Continued Cylinder Storage at Paducah, Portsmouth, and K-25			
The entire cylinder inventory would continue to be stored indefinitely at the Paducah, Portsmouth, and K-25 sites (impacts were evaluated from 1999 through 2039). Cylinders would be subject to a comprehensive monitoring and maintenance program, which would include routine inspections, cylinder painting, and cylinder yard upgrades.	The entire cylinder inventory would continue to be stored at the three current storage sites from 1999 through 2008. The inventory at each site was assumed to decrease to zero cylinders over the period 2009 through 2034 as cylinders were shipped to an off-site location.[a] During storage at current locations, cylinders would be subject to similar management activities as under no action.	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative
		Cylinder Preparation for Transportation			
Not applicable. The cylinders would remain at the three current storage sites.	The cylinders would be prepared at each current storage site for off-site shipment. Cylinders not suitable for shipment would either be provided with over-containers or the contents would be transferred to new cylinders.	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative
		Conversion			
Not applicable.	Not applicable.	UF_6 would be converted to uranium oxide (U_3O_8 or UO_2) at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to the oxide UO_2 at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to uranium metal at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to uranium oxide (U_3O_8 or UO_2) at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]

TABLE 2.1 (Cont.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Consolidated Long-Term Storage			
Not applicable. Cylinders would remain at the three current storage sites.	UF_6 cylinders would be stored for the long term in yards, buildings, or a mine at a site to be determined in the future. Cylinders would be placed into storage over the period 2009 through 2034 and remain through 2039.[a]	Oxide (either U_3O_8 or UO_2) would be stored for the long term in drums in buildings, belowground vaults, or a mine at a site to be determined in the future. Material would be placed into storage over the period 2009 through 2034 and remain through 2039.[a]	Not applicable.	Not applicable.	Not applicable.
		Manufacture and Use			
Not applicable.	Not applicable.	Not applicable.	Depleted uranium oxide (UO_2) would be manufactured into casks for storage of spent nuclear fuel or HLW at a site to be determined. Manufacture would occur from 2009 through 2034.[a]	Depleted uranium metal would be manufactured into casks for storage of spent nuclear fuel or HLW at a site to be determined. Manufacture would occur from 2009 through 2034.[a]	Not applicable.
		Disposal of Uranium			
Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Uranium oxide (either U_3O_8 or UO_2) would be disposed of as LLW at a site to be determined in the future. Disposal was considered for grouted (immobilized) and ungrouted oxide (in drums) in shallow earthen structures, below-ground vaults, and a mine.

TABLE 2.1 (Cont.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Transportation[b]			
Small amounts of LLW and LLMW would be shipped from the current storage sites to treatment/disposal site(s).	UF_6 cylinders would be shipped from the current storage sites to a long-term storage site. LLW/LLMW would be shipped from storage sites to a disposal/treatment site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site. Uranium oxide (U_3O_8 or UO_2) would be shipped from a conversion site to a long-term storage site. HF (if produced) would be shipped from a conversion site to a user site. CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site. NH_3 would be shipped from a supplier to a conversion site. LLW/LLMW would be shipped from conversion/ storage sites to a disposal/ treatment site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site. Uranium oxide (UO_2) would be shipped from a conversion site to a manufacturing site. HF (if produced) would be shipped from a conversion site to a user site. CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site. NH_3 would be shipped from a supplier to a conversion site. LLW/LLMW would be shipped from conversion/ storage/manufacturing sites to a disposal/treatment site. Casks would be shipped from a manufacturing site to a user site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site. Uranium metal would be shipped from a con-version site to a manufacturing site. HF (if produced) would be shipped from a conversion site to a user site. CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site. NH_3 would be shipped from a supplier to a conversion site. LLW/LLMW would be shipped from conversion/ storage/manufacturing sites to a disposal/treatment site. Casks would be shipped from a manufacturing site to a user site. MgF_2 would be shipped from a conversion site to a disposal site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site. Uranium oxide (U_3O_8 or UO_2) would be shipped from a conversion site to a disposal site. HF (if produced) would be shipped from a conversion site to a user site. CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site. NH_3 would be shipped from a supplier to a conversion site. LLW/LLMW would be shipped from conversion/ storage sites to a disposal/ treatment site.

[a] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

[b] Because the locations of conversion, manufacture, long-term storage, and disposal sites will be decided in future studies, it was assumed that these sites were at separate locations, requiring transportation between them. This approach was intended to provide a conservative estimate of potential transportation impacts. Colocation of facilities would reduce transportation impacts.

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride; UO_2 = uranium dioxide; U_3O_8 = triuranium octaoxide.

presented in Chapter 5 and Chapter 6. Chapter 5 evaluates the potential impacts associated with the management of DOE-generated UF_6 (i.e., 46,422 cylinders), which was the original scope of the PEIS. Chapter 6, which was added to the PEIS following the public comment period, discusses the potential impacts that would result from the additional management of up to 15,000 USEC-generated cylinders. In general, it was assumed that the processing of the USEC-generated inventory would be accomplished by extending the operational period of required facilities from 20 to 26 years. In most cases, the impacts associated with this processing were estimated by extrapolating the results determined for the DOE-generated inventory. (See Chapter 6 for more details.)

The potential environmental impacts for each alternative have been estimated in the areas of human health and safety (normal operations and accidents), air quality, water and soil, socioeconomics, ecology, waste management, resource requirements, land use, cultural resources, and environmental justice. The assessment considered impacts that could result from construction of necessary facilities, normal operations of facilities, facility accidents, and transportation (including routine and accident conditions) of materials. Potential impacts during continued cylinder storage and cylinder preparation for shipment activities were evaluated for the site-specific conditions at the three current storage sites. Potential impacts of conversion, manufacture and use, long-term storage, and disposal activities were evaluated for representative or generic environmental settings. The environmental setting for each site is described in Chapter 3, and the methods used to evaluate each resource area are described in Chapter 4.

The analysis in the PEIS was intended to provide a comparison of reasonably foreseeable environmental impacts for each of the alternatives considered. Consequently, the potential environmental impacts were evaluated for the period 1999 through 2039 for all alternatives. In addition to this analysis, an evaluation of the long-term impacts from disposal (up to a period of 1,000 years beyond the assumed failure of a disposal facility) was included in the PEIS because such impacts are reasonably foreseeable. Long-term impacts from potential groundwater contamination were also evaluated for the continued storage component of all alternatives.

For all alternatives other than disposal, depleted uranium would require continued management beyond the time frame of approximately 40 years considered in this PEIS. However, a quantitative life-cycle evaluation was not considered at this time because actions to be taken beyond the time period considered in the analysis are considered highly uncertain and speculative. To address such issues, a discussion related to potential life-cycle impacts and the final disposition of products containing depleted uranium is summarized in Section 2.6 and discussed in more detail in Section 5.9.

A comparison of the estimated environmental impacts associated with management of the DOE-generated cylinders only and for the total cylinder inventory (DOE-generated plus USEC-generated) for each alternative is provided in Table 2.2. Table 2.3 summarizes separately the additional impacts that would be associated with the management of up to 15,000 USEC-generated cylinders. The preferred alternative, which combines aspects of several of the alternatives evaluated

TABLE 2.2 Summary Comparison of Potential Environmental Consequences of Alternative Management Strategies[a]

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
	Human Health and Safety — Normal Facility Operations[b]					
Radiation Exposure						
Involved workers						
Annual dose to individual workers	Monitored to be maintained within regulatory limit of 5 rem/yr or lower	Same as NAA[c]	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total health effects among involved workers (1999–2039)	1 additional LCF	1 additional LCF [1 to 2 additional LCFS]	1 to 2 additional LCFs [1 to 3 additional LCFs]	1 to 2 additional LCFs	1 to 2 additional LCFs	1 to 2 additional LCF [1 to 3 additional LCFs]
Noninvolved workers						
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total health effects among noninvolved workers (1999–2039)	0 additional LCFs from routine site emissions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
General public						
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Operational Phase: Same as NAA. Postclosure Phase: Same as NAA for a disposal facility located in a dry environmental setting. In a wet environmental setting, the maximum dose from the use of groundwater was estimated to be about 100 mrem/yr within 1,000 years of facility failure.
Total health effects among members of the public (1999–2039)	0 additional LCFs from routine site emissions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical Exposure of Concern (Concern = hazard index > 1)						
Noninvolved worker MEI[d]	No (Hazard Index <1)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
Human Health and Safety — Normal Facility Operations[b] (Cont.)						
General public MEI	No (Hazard Index <1)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Operational Phase: Same as NAA. Postclosure Phase: Same as NAA in a dry environmental setting. In a wet environmental setting, a hazard index of about 10 was estimated within 1,000 years of facility failure.
Human Health and Safety — Facility Accidents[b]						
Physical Hazards from Construction and Operations (involved and noninvolved workers)						
On-the-job fatalities and injuries (1999–2039)	0 fatalities; 140 injuries [0 fatalities; 180 injuries]	0–1 fatality; 240–900 injuries [1–2 fatalities; 310–1,200 injuries]	1–2 fatalities; 700–1,600 injuries [1–3 fatalities; 900–2,100 injuries]	2–3 fatalities; 1,300–2,000 injuries [2–3 fatalities; 1,600–2,600 injuries]	2–3 fatalities; 1,300–2,100 injuries [2–3 fatalities; 1,700–2,700 injuries]	1–3 fatalities; 700–1,800 injuries [1–3 fatalities; 900–2,400 injuries]
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites						
Likely Cylinder Accidents[e]						
Accident[f]	Corroded cylinder spill, dry conditions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Release	Uranium, HF	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Estimated frequency	~ 1 in 10 years	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident probability (1999–2039)	4 potential accidents	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Consequences (per accident)						
Chemical exposure – public	No adverse effects	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical exposure – noninvolved workers[g]						
Adverse effects	70	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	3	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)						
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Likely Cylinder Accidents[e] (Cont.)						
Radiation exposure – public						
Dose to MEI	3 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	1 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to population	0.4 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Radiation exposure – noninvolved workers[g]						
Dose to MEI	77 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	3 in 100,000	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to workers	2.2 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Workers	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Low Frequency-High Consequence Cylinder Accidents[h]						
Accidents[f]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Release	Uranium, HF	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Estimated frequency	~ 1 in 100,000 years	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	1	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical exposure – noninvolved workers[g]						
Adverse effects	1,000	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	300	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	3	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)						
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Radiation exposure – public						
Dose to MEI	15 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	7 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to population	1 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Radiation exposure – noninvolved workers[g]						
Dose to MEI	20 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	8 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to workers	16 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Noninvolved workers	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[h]						
Chemical accident[f]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as NAA	HF or NH_3 tank rupture	Same as LTSO[c]	Same as LTSO	Same as LTSO
Release	Uranium, HF	Same as NAA	HF, NH_3	Same as LTSO	Same as LTSO	Same as LTSO
Accident location	Current storage site	Same as NAA	Conversion site	Same as LTSO	Same as LTSO	Same as LTSO
Estimated frequency	~ 1 in 100,000 years	Same as NAA	< 1 in 1 million years	Same as LTSO	Same as LTSO	Same as LTSO
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	1 chance in 50,000	Same as LTSO	Same as LTSO	Same as LTSO
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as NAA	41,000	Same as LTSO	Same as LTSO	Same as LTSO
Irreversible adverse effects	1	Same as NAA	1,700	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	0	Same as NAA	30	Same as LTSO	Same as LTSO	Same as LTSO
Chemical exposure – noninvolved workers[g]						
Adverse effects	1,000	Same as NAA	1,100	Same as LTSO	Same as LTSO	Same as LTSO
Irreversible adverse effects	300	Same as NAA	440	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	3	Same as NAA	4	Same as LTSO	Same as LTSO	Same as LTSO

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Facility Accidents[b] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[h] (Cont.)						
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	0 fatalities	Same as LTSO	Same as LTSO	Same as LTSO
Noninvolved workers[g]	0 fatalities	Same as NAA	0 fatalities	Same as LTSO	Same as LTSO	Same as LTSO
Radiological accident[f]	Vehicle-induced fire, 3 full cylinders	Same as NAA	Earthquake damage to storage building at conversion site	Earthquake damage to storage building at conversion site	Vehicle-induced fire, 3 full cylinders	Same as LTSO
Release	Uranium	Same as NAA	Uranium (U_3O_8)	Uranium (UO_2)	Uranium	Same as LTSO
Accident location	Current storage site	Same as NAA	Conversion site	Conversion site	Conversion site	Same as LTSO
Estimated frequency	~ 1 in 100,000 years	Same as NAA	1 in 100,000 years	1 in 100,000 years	1 in 100,000 years	Same as LTSO
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	1 chance in 5,000	1 chance in 5,000	1 chance in 5,000	Same as LTSO
Consequences (per accident)						
Radiation exposure – public						
Dose to MEI	15 mrem	Same as NAA	270 mrem	68 mrem	15 mrem	Same as LTSO
Risk of LCF	7 in 1 million	Same as NAA	1 in 10,000	3 in 100,000	7 in 1 million	Same as LTSO
Total dose to population	28 person-rem	Same as NAA	20 person-rem	5.1 person-rem	56 person-rem	Same as LTSO
Total LCFs	0	Same as NAA	0	0	0	Same as LTSO
Radiation exposure – noninvolved workers[g]						
Dose to MEI	20 mrem	Same as NAA	9,000 mrem	2,300 mrem	20 mrem	Same as LTSO
Risk of LCF	8 in 1 million	Same as NAA	1 in 250	9 in 10,000	8 in 1 million	Same as LTSO
Total dose to workers	16 person-rem	Same as NAA	840 person-rem	210 person-rem	8 person-rem	Same as LTSO
Total LCFs	0	Same as NAA	0	0	0	Same as LTSO
Accident risk (consequence times probability)						
General public	0 LCFs	Same as NAA	0 LCFs	0 LCFs	0 LCFs	Same as LTSO
Noninvolved workers[g]	0 LCFs	Same as NAA	0 LCFs	0 LCFs	0 LCFs	Same as LTSO

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Transportation[b]			
Major Materials Assumed to Be Transported between Sites	LLW/LLMW	UF_6 cylinders LLW/LLMW	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW Casks	UF_6 cylinders Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW
Normal Operations						
Fatalities from exposure to vehicle exhaust and external radiation	0	0	0 to 1	0 to 1	0 to 1	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Negligible	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo)						
Maximum use of trucks	Negligible	2 fatalities	4 fatalities	4 fatalities	3 fatalities [4 fatalities]	4 fatalities
Maximum use of rail	Negligible	1 fatality	2 fatalities	2 fatalities [3 fatalities]	1 fatality [2 fatalities]	2 fatalities
Traffic Accidents Involving Releases of Radiation or Chemicals						
Low Frequency-High Consequence Cylinder Accidents						
Accident	Not applicable	Urban rail accident involving 4 cylinders	Same as $LTSUF_6$[c]	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Release	Not applicable	Uranium, HF	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Accident probability (1999–2039)	Not applicable	1 chance in 10,000	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
Human Health and Safety — Transportation[b] (Cont.)						
Traffic Accidents Involving Releases of Radiation or Chemicals (Cont.)						
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	Not applicable	4	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Fatalities	Not applicable	0	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Radiation exposure – All workers and members of general public						
Total LCFs	Not applicable	60	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Accident risk (consequence times probability) – Workers and general public	Not applicable	0 fatalities	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Low Frequency-High Consequence Accidents with All Other Materials						
Accident	Not applicable	Not applicable	Urban rail accident involving anhydrous HF	Same as LTSO	Same as LTSO	Same as LTSO
Release	Not applicable	Not applicable	Anhydrous HF	Same as LTSO	Same as LTSO	Same as LTSO
Accident probability (1999–2039)	Not applicable	Not applicable	1 chance in 30,000	Same as LTSO	Same as LTSO	Same as LTSO
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	Not applicable	Not applicable	30,000	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	Not applicable	Not applicable	300	Same as LTSO	Same as LTSO	Same as LTSO
Accident risk (consequence times probability)						
Irreversible adverse effects	Not applicable	Not applicable	1	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	Not applicable	Not applicable	0	Same as LTSO	Same as LTSO	Same as LTSO

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Air Quality			
Current Storage Sites						
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 23% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities[i]						
Pollutant emissions during construction and operations	Not applicable	Pollutant emissions well within standards (all less than 20% of standards)	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)	Same as LTSO	Same as LTSO	Same as LTSO

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
Water and Soil[j]						
Current Storage Sites						
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other parameters[k]	No change	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]						
Surface water, groundwater, and soil quality	Not applicable	Site-dependent; contaminant concentrations could be kept within guideline levels	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Uranium concentration in groundwater would remain within guideline for more than 1,000 years after failure in a dry environmental setting; could exceed guideline before 1,000 years after failure in a wet setting
Other parameters[k]	No change	Site-dependent; none to moderate impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Site-dependent; negligible to moderate impacts
Excavation of Soil for Long-Term Storage or Disposal	Not applicable	Change in topography from 160,000 to 1.8 million yd^3 of excavated material [210,000 to 2.1 million yd^3]	Change in topography from 81,000 to 2.2 million yd^3 of excavated material [100,000 to 2.6 million yd^3]	Not applicable	Not applicable	Change in topography from 300,000 to 2.6 million yd^3 of excavated material [400,000 to 3.6 million yd^3]

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
		Socioeconomics [l]				
Current Storage Sites						
Continued storage	**Jobs:** 30 peak year, construction; 110 per year over 40 years, operations [38 peak year, construction; 140 per year over 40 years, operations]	**Jobs:** 30 peak year, construction; 120 per year over 20 years, operations [38 peak year, construction; 150 per year over 26 years, operations]	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
	Income: $1.4 million peak year, construction; $5.1 million per year over 40 years, operations [$1.8 million peak year, construction; $6.0 million per year over 40 years, operations]	**Income:** $1.4 million peak year, construction; $6 million per year over 20 years, operations [$1.8 million peak year, construction; $7 million per year over 26 years, operations]				
Cylinder preparation	Not applicable	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 20 years, operations [over 26 years, operations]	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
		Income: $0–26 million peak year, preoperations; $19–25 million per year over 20 years, operations [over 26 years, operations]				

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Socioeconomics [l] ***(Cont.)***			
Other Facilities						
Conversion (Site undetermined)	Not applicable	Not applicable	**Jobs:** 340–730 peak year, construction; 330–490 per year over 20 years, operations [over 26 years, operations] **Income:** $16–33 million peak year, construction; $20–28 million per year over 20 years, operations [over 26 years, operations]	Same as LTSO	**Jobs:** 480–540 peak year, construction; 340–500 per year over 20 years, operations [over 26 years, operations] **Income:** $17–21 million peak year, construction; $20–28 million per year over 20 years, operations [over 26 years, operations]	Same as LTSO
Long-term storage (Site undetermined)	Not applicable	**Jobs:** 100–500 peak year, construction; 50–60 per year over 30 years, operations [60–70 per year over 30 years, operations] **Income:** $5–29 million peak year, construction; $3 million per year over 30 years, operations [$4 million per year over 30 years, operations]	**Jobs:** 120–410 peak year, construction; 60–70 per year over 30 years, operations [70–80 per year over 30 years, operations] **Income:** $5–20 million peak year, construction; $3–4 million per year over 30 years, operations [$4–5 million per year over 30 years, operations]	Not applicable	Not applicable	Not applicable

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Socioeconomics [l] ***(Cont.)***			
Other Facilities (Cont.) Manufacturing (Site undetermined)	Not applicable	Not applicable	Not applicable	**Jobs:** 160 peak year, construction; 470 per year over 20 years, operations [over 26 years, operations] **Income:** \$7 million peak year, construction; \$33 million per year over 20 years, operations [over 26 years, operations]	**Jobs:** 190 peak year, construction; 470 per year over 20 years, operations [over 26 years, operations] **Income:** \$9 million peak year, construction; \$33 million per year over 20 years, operations [over 26 years, operations]	Not applicable
Disposal (Site undetermined)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	**Jobs:** 65–770 peak year, construction; 60–180 per year over 20 years, operations [over 26 years, operations] **Income:** \$3.5–42 million peak year, construction; \$6–18 million per year over 20 years, operations [over 26 years operations]

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Ecology			
Current Storage Sites						
Habitat loss	Up to 7 acres; negligible impacts	Up to 28 acres; negligible to potential moderate impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility accidents	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Wetlands and threatened or endangered species	None to negligible impacts	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]						
Habitat loss[m]	Not applicable	**Long-term storage:** 96–144 acres; potential moderate to large impacts to vegetation and wildlife [110–170 acres; potential large impacts]	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Long-term storage:** 75–210 acres; potential moderate to large impacts to vegetation and wildlife [80–260 acres; moderate to large impacts]	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** 90 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** 30–35 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** 90 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Disposal:** 30–470 acres; potential moderate to large impacts to vegetation and wildlife [40–590 acres; moderate to large impacts]
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility accidents	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Below harmful levels for more than 1,000 years in a dry environmental setting; potential chemical effects on aquatic biota before 1,000 years after failure in a wet setting; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Not applicable	Site-dependent; avoid or mitigate	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Waste Management			
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (increase of about 20%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation [increase of about 30% in LLMW generation at the Paducah site]	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]	Not applicable	**Long-term storage:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) as LLW (if required); potential moderate impact to site waste generation for CaF_2 as nonhazardous solid waste **Long-term storage:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Same as LTSO **Manufacturing:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Potential moderate impacts to current nationwide LLW generation for MgF_2 as LLW (if required); potential moderate impact to site waste generation for MgF_2 as nonhazardous solid waste **Manufacturing:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Same as LTSO **Disposal:** Negligible to low impacts with respect to both current and projected nationwide waste generation

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Resource Requirements [n]			
All Sites	No effects on local, regional, or national availability of materials are expected	No effects on local, regional, or national availability of materials are expected; impacts of electrical requirements for mine excavation dependent on site location	Same as $LTSUF_6$	Same as NAA	Same as NAA	Same as $LTSUF_6$
			Land Use [m]			
Current Storage Sites	Up to 7 acres; less than 1% of available land; negligible impacts	Up to 28 acres; less than 1% of available land; negligible impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities[i]	Not applicable	**Long-term storage:** 96–144 acres; potential moderate impacts [110–170 acres; potential moderate impacts]	**Conversion:** 30–40 acres; negligible impacts **Long-term storage:** 75–210 acres; potential moderate to large impacts [80–260 acres; moderate to large impacts]	**Conversion:** 30–40 acres; negligible impacts **Manufacturing:** 90 acres; potential moderate impacts	**Conversion:** 30–35 acres; negligible impacts **Manufacturing:** 90 acres; potential moderate impacts	**Conversion:** 30–40 acres; negligible impacts **Disposal:** 30–470 acres; potential moderate to large impacts [40–590 acres; potential moderate to large impacts]
			Cultural Resources			
Current Storage Sites	Impacts unlikely	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]	Not applicable	Impacts dependent on location; avoid and mitigate	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
Environmental Justice						
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

[a] In general, the overall environmental consequences from managing the total cylinder inventory (total of USEC-generated and DOE-generated cylinders) are the same as those from managing the DOE-generated cylinders only. In this table, when the consequences for the total inventory differ from those for the DOE-generated cylinders only, the consequences for the total inventory are presented in brackets following the consequences for DOE cylinders only.

[b] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

[c] LTSO = long-term storage as oxide alternative; $LTSUF_6$ = long-term storage as UF_6 alternative; NAA = no action alternative.

[d] Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[e] Accidents with probabilities of occurrence greater than 0.01 per year.

[f] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[g] In addition to noninvolved worker impacts, chemical and radiological exposures for involved workers under accident conditions (workers within 100 m of a release) would depend in part on facility designs and other factors (see Section 4.3.2.1).

[h] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[i] Other facilities are facilities for conversion, long-term storage, manufacturing, and disposal.

[j] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed EPA maximum contaminant level of 20 µg/L (EPA 1996); this value is an applicable standard for water “at the tap” of the user, and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 µg/g.

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TABLE 2.2 (Cont.)

Foonotes (Cont.)

[k] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

[l] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages, except for continued storage, which is reported for the peak year of operations.

[m] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

[n] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride.

TABLE 2.3 Additional Impacts Associated with the Management of up to 15,000 USEC-Generated Cylinders[a]

Impact Area	Impacts Associated with Management of USEC-Generated Cylinders
Human Health and Safety	
Normal Operations	Under all alternatives, an increase in the total level of radiation exposure of about 30% could result in 0 to 1 additional latent cancer fatality for involved workers. For noninvolved workers and the general public, the increased level of exposure would not be large enough to cause appreciable increases in the potential health impacts.
Facility Accidents	
• Physical Hazards (on-the-job fatalities and injuries)	The total estimated fatalities and injuries would increase by about 30%, resulting in 0 to 1 additional fatality and 40 to 1,000 additional on-the-job injuries under all alternatives.
• Accidents Involving Releases of Radiation or Chemicals	Under all alternatives, accident consequences would be the same as those predicted for the DOE-generated cylinders only (see Table 2.2), because a limited amount of material would be at risk regardless of the number of cylinders in storage. The frequencies of some facility accidents could increase; however, this increase would not be enough to change the overall expected frequency of specific accidents from the broad ranges used for analysis.
Transportation	The estimated numbers of fatalities from truck and rail accidents would increase by about 30%, which would result in 0 to 1 additional fatality under each alternative. No increase in the number of fatalities from radiological exposures or vehicle emissions during routine operations would be expected. The consequences of severe traffic accidents involving releases of radiation or chemicals would be the same as those predicted for the shipment of DOE-generated cylinders, because the shipment sizes would not change (Table 2.2). The total probability of a severe accident would increase by about 30% as shipments continued for an additional 6 years.
Air Quality	At the Paducah and Portsmouth sites, predicted air concentrations of HF could increase as a result of the continued storage of the USEC-generated cylinders. These increases would not result in exceedance of standards or guidelines. Concentrations of criteria pollutants would not exceed guidelines. Under alternatives involving conversion, long-term storage, manufacture, or disposal, the annual uranium emissions would remain unchanged, although total uranium emissions would increase by about 30% as a result of the lengthened period of operations. However, the increase in uranium emissions would not increase the estimated number of adverse health effects.

TABLE 2.3 (Cont.)

Impact Area	Impacts Associated with Management of USEC-Generated Cylinders
Water and Soil	At the current storage sites, the estimated maximum groundwater concentrations of uranium that would result from releases from hypothetical cylinder breaches would be the same as the bounding values estimated for the DOE-generated cylinders only. Potential surface water, groundwater, and soil quality impacts at conversion, long-term storage, and manufacturing facilities would be site-dependent; however, on the basis of evaluations of representative and generic sites, contaminant concentrations would be expected to remain within guideline levels under all alternatives. For disposal, the estimated groundwater concentrations of uranium during the postclosure (long-term) time frame could increase by about 20% over those estimated for the DOE cylinders only. This increase would not change the overall impact assessment (i.e., guidelines could be exceeded in a wet environment before 1,000 years, but would not be exceeded in a dry environment for more than 1,000 years). Under alternatives involving long-term storage or disposal, soil excavation volumes would increase by about 35% for some options.
Socioeconomics	At the current storage sites, the number of direct jobs and income would increase by about 30%. The annual impacts for conversion, manufacturing, and disposal facilities would not change, but the period of operations would increase by about 6 years. For long-term storage and disposal facilities, the period of construction would also increase by about 6 years. Also, surveillance and maintenance impacts for long-term storage facilities would increase by about 30%.
Ecology	Concentrations of uranium in soil, groundwater, or surface water would remain below benchmark values for toxic and radiological effects under all alternatives except the disposal alternative (in a wet environment). The adverse impact from disposal would be present whether or not the USEC cylinders are included. Under alternatives involving long-term storage or disposal, additional habitat loss would result from additional land use requirements. However, the overall impacts assessment (i.e, negligible, moderate, or large impacts to vegetation or wildlife) would not change under any of the alternatives.
Waste Management	Total waste generation would increase by about 30% as a result of the operation of facilities for 6 additional years. However, the general waste management impacts under each alternative would be the same as those estimated for the DOE cylinders only. For example, waste management impacts when considered in terms of national and regional waste management capabilities would still be low to moderate under alternatives involving conversion and/or disposal because of the potential disposal of CaF_2, MgF_2, and depleted uranium oxides as LLW.

TABLE 2.3 (Cont.)

Impact Area	Impacts Associated with Management of USEC-Generated Cylinders
Resource Requirements	In general, no change in impacts would occur with respect to resource requirements, because the construction and operational requirements would not be resource intensive, and the resources required would not be considered rare or unique. Already large electrical requirements for mine construction would be increased by approximately 15%, but the impacts of the electrical requirements would be site-specific.
Land Use	Under alternatives involving long-term storage or disposal, additional land use requirements would range from 9 to 33% for the various options. However, the overall impacts assessment (i.e, negligible, moderate, or large impacts) would not change under any of the alternatives.
Cultural Resource	The impacts assessment for cultural resources would be the same as that presented for management of DOE-generated cylinders (Table 2.2).
Environmental Justice	The impacts assessment for environmental justice would be the same as that presented for management of DOE-generated cylinders (Table 2.2).

[a] In general, it was assumed that the processing of the USEC-generated inventory would be accomplished by extending the operational period of required facilities from 20 to 26 years. In most cases, the impacts associated with this processing were estimated by extrapolating the results determined for the DOE-generated inventory. (See Chapter 6 for more details.)

in the PEIS, is discussed separately in Section 2.5. (Detailed discussions of the impacts of the preferred alternative are provided in Section 5.7 and Section 6.3.7.)

To supplement the information in Tables 2.2 and 2.3, each area of impact evaluated in the PEIS is discussed separately in Sections 2.4.1 through 2.4.12. Major similarities and differences among the alternatives are highlighted. The impacts associated with the processing of DOE-generated cylinders are generally discussed first, followed by a summary of the total impacts considering the processing of USEC-generated cylinders. Chapter 5 provides additional details related to management of the DOE-generated cylinders for each alternative, as well as discussions of potential mitigative measures, cumulative impacts, issues related to potential life-cycle impacts, irreversible and irretrievable commitment of resources, the relationship between short-term use of the environment and long-term productivity, pollution prevention, and waste minimization. Chapter 6 provides details related to the additional impacts associated with the management of the USEC-generated inventory and the impacts of managing the total inventory (DOE-generated plus USEC-generated inventory). Changes in cumulative impacts are also discussed in Chapter 6.

2.4.1 Human Health and Safety — Normal Facility Operations

For all alternatives, exposures of workers and members of the public to radiation and chemicals were estimated to be within applicable public health standards and regulations during normal facility operations. Levels of radiation and/or chemical exposures for the general public and noninvolved workers for all alternatives during normal facility operations were estimated to be very low, with zero latent cancer fatalities (LCFs) expected among these groups over the duration of the program. Involved workers (persons directly involved in the handling of radioactive or hazardous materials) could be exposed to low-level radiation emitted by uranium during the normal course of their work activities, and this exposure could result in a slight increase in the risk for radiation-induced cancer fatality among the involved worker population. The annual number of workers so exposed could range from about 50 (under the no action alternative) to about 700 (under the use as metal alternative.) For management of DOE-generated cylinders, the increased exposure to radiation resulted in an estimated range of zero to one involved worker cancer fatality (under the no action alternative) to a range of one to two involved worker cancer fatalities (under the long-term storage as oxide, use as uranium oxide, use as metal, and disposal alternatives) over the assessment period.

Possible radiological exposures from the use of groundwater were also evaluated. For all alternatives except the disposal as oxide alternative, these exposures were estimated to be within applicable public health standards and regulations. During the operational phase of the disposal as oxide alternative, exposures were also estimated to remain within standards and regulations. Although design criteria are such that disposal facilities would not be expected to fail (that is, release material to the environment) until several hundred years after closure, for purposes of analysis, it was assumed that these facilities would fail 100 years after closure. For the disposal as oxide alternative, if the disposal facility was located in a "wet" environment (typical of the eastern United States), the estimated dose at 1,000 years after disposal facility failure from the use of groundwater would be about 100 mrem/yr, which would exceed the dose limit of 25 mrem/yr specified in 10 CFR Part 61 and DOE Order 5820.2A. In addition, the groundwater concentrations would be great enough to cause potential adverse effects from chemical exposures. The chemical hazard indices would range up to 10, indicating the potential for chemically induced adverse effects. The groundwater analysis indicated that if disposal occurred in a dry environmental setting (typical of the western United States), no measurable groundwater contamination would have occurred at 1,000 years after failure of the disposal facility, because of the small amount of rainfall and large distance to the groundwater table typical of a dry environment.

Under all alternatives, consideration of the management of up to 15,000 USEC-generated cylinders would increase the total radiation exposure by about 30%, which would correspond to 0 to 1 additional LCF among involved workers. The total estimated number of health effects among involved workers would range from about 1 LCF under the no action alternative to up to 3 LCFs under the long-term storage as oxide and disposal alternatives. For noninvolved workers and the general public, the increased levels of exposure resulting from the management of USEC-generated cylinders would not be large enough to make a difference in the potential health impacts reported for DOE-generated cylinders only. In addition, although the estimated groundwater concentrations of uranium at 1,000 years postclosure of a disposal facility would increase by about 20%, this increase would not change the assessment that the dose to a member of the public could exceed specified limits in a wet disposal environment but not in a dry environment.

2.4.2 Human Health and Safety — Facility Accidents

2.4.2.1 Physical Hazards

Under all alternatives, workers (including involved and noninvolved) could be injured or killed from on-the-job accidents unrelated to radiation or chemical exposure. For the management of DOE-generated cylinders and on the basis of statistics for similar industries, under the no action alternative, it was estimated that zero fatalities and about 140 injuries might occur over the period 1999 through 2039. Under all other alternatives, it was estimated that from zero to three fatalities and from 240 to 2,100 injuries might occur over the same period. Accidental injuries and deaths are not unusual in industries using heavy equipment to manipulate heavy objects and bulk materials. The differences among the alternatives reflect differences in the total number of work hours that would be required.

Management of up to 15,000 USEC-generated cylinders would increase the total number of estimated fatalities and injuries among workers. This increase would result in 1 additional estimated fatality for the long-term storage as UF_6 alternative and for the long-term storage as oxide alternative. (No additional fatalities were estimated for the other alternatives because of rounding effects and the fact that fatality estimates are presented as single whole numbers.) From about 40 to about 1,000 additional on-the-job injuries would be expected across all alternatives (see Table 2.2). Thus, total impacts (including both DOE- and USEC-generated cylinders) would range from 0 to 3 additional fatalities and from 180 to 2,700 injuries across all alternatives.

2.4.2.2 Facility Accidents Involving Releases of Radiation or Chemicals

Under all alternatives, accidents are possible that could release radiation or chemicals to the environment, potentially causing adverse health effects among workers and members of the public. Of all the accidents considered, those involving depleted UF_6 cylinders and those involving chemicals at a conversion facility were estimated to have the largest potential adverse effects.

Under all alternatives, accidents involving UF_6 cylinders could occur at the current storage sites because continued storage of cylinders is a component of all of the alternatives. In addition, cylinder accidents could occur at a consolidated long-term storage facility and at a conversion facility. Cylinder accidents could release UF_6 to the environment. If a release occurred, the UF_6 would combine with moisture in the air, forming gaseous HF and uranyl fluoride (UO_2F_2), a soluble solid in the form of small particles. The depleted uranium and HF could be dispersed downwind, potentially exposing workers and members of the general public to radiation and chemical effects. The amount released would depend on the severity of the accident and the number of cylinders involved. The potential consequences of cylinder accidents are presented in Table 2.2 for (1) accidents that might happen at least once in 100 years ("likely" accidents; assumed frequency of once in 10 years for probability calculations) and (2) accidents that might happen much less frequently, from once in 10,000 to less than once in 1 million years (assumed frequency of once in 100,000 years for probablity calculations).

For releases involving UF_6 and other uranium compounds, both chemical and radiological adverse effects could occur if the material was ingested or inhaled. The chemical adverse effect of most concern associated with uranium exposure is kidney damage, and the radiological adverse effect is increased rate of cancer fatalities. Chemical effects (kidney damage) occur at lower exposure levels than radiological effects. Exposure to HF from accidental releases could result in a range of health effects, from eye and respiratory irritation to death, depending on the exposure level.

Chemical and radiological exposures for involved workers (those within 100 m of the release) under accident conditions would depend on how rapidly the accident developed, the exact location and response of the workers, the direction and amount of the release, the physical forces causing or caused by the accident, meteorological conditions, and characteristics of the room or building if the accident occurred indoors. Impacts to involved workers under accident conditions would likely be dominated by physical forces from the accident itself, so that quantitative dose/effect estimates would not be meaningful. For these reasons, the impacts to involved workers during accidents are not quantified in this PEIS. However, it is recognized that injuries and fatalities among involved workers would be possible if an accident did occur.

For accidents involving cylinders that might happen at least once in 100 years ("likely" accidents), the off-site concentrations of HF and uranium were estimated to be considerably below levels that would cause adverse chemical effects among members of the general public from exposure to these chemicals. However, up to 70 noninvolved workers might experience potential adverse effects from exposure to HF and uranium (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). It was estimated that three noninvolved workers might experience potential irreversible adverse effects that are permanent in nature (such as lung damage or kidney damage), with no fatalities among these workers expected. Radiation exposures were estimated to result in no additional cancer fatalities among noninvolved workers or members of the general public.

Cylinder accidents that are less likely to occur could have greater consequences and could affect off-site members of the general public. These types of accidents are considered extremely unlikely, expected to occur with a frequency of between once in 10,000 and once in 1 million per year of operations. Over the period 1999 through 2039, the probability of this type of accident would be about 1 chance in 2,500. Among all the accidents analyzed, the accident resulting in the largest number of people with adverse effects (including mild and temporary, as well as permanent effects) was a vehicle-induced fire involving three cylinders. If this accident occurred, it was estimated that up to 1,900 members of the general public and 1,000 noninvolved workers might experience adverse chemical effects from HF and uranium exposure (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). More adverse effects are estimated among the general public than among noninvolved workers because of buoyancy effects of the fire on contaminant plume spread (that is, concentrations that occur are higher at points distant from the release than at closer locations).

The modeled accident resulting in the largest number of persons with irreversible adverse health effects was a corroded cylinder spill under wet conditions. If this accident occurred, it was estimated that 1 member of the general public and 300 noninvolved workers might experience irreversible adverse effects (such as lung damage or kidney damage). No fatalities would be expected among the public; there would be a potential for three fatalities among noninvolved workers from chemical effects. Radiation exposures were estimated to result in no additional cancer fatalities among noninvolved workers or the general public.

The number of persons actually experiencing adverse or irreversible adverse effects from cylinder accidents would likely be considerably fewer than those estimated for this analysis and would depend on the actual circumstances of the accident and the individual chemical sensitivities of the affected persons. For example, although exposures to releases from cylinder accidents could be life-threatening (especially with respect to immediate effects from HF inhalation), the guideline exposure level of 20 parts per million (ppm) for HF (American Industrial Hygiene Association [AIHA] 1996), which is used to estimate irreversible adverse effects from HF exposure, is likely to result in overestimates. This is because no deaths have been known to occur as a result of acute exposures (i.e., 1 hour or less) of animals or humans at concentrations of less than 50 ppm (AIHA 1988), and generally, if death does not occur quickly after HF exposure, recovery is complete (McGuire 1991).

The guideline intake level of 30 mg used to estimate irreversible adverse effects of uranium in this PEIS is that suggested in NRC guidance (NRC 1994a). This level is somewhat conservative; that is, it is intended to overestimate rather than underestimate the potential number of irreversible adverse effects in the exposed population. In nearly 40 years of cylinder handling activities, no accidents involving releases from cylinders containing *solid* UF_6 have occurred that have caused diagnosed irreversible adverse effects among workers. In previous accidental exposure incidents involving *liquid* UF_6 in gaseous diffusion plants, some worker fatalities occurred immediately following the accident as a result of inhalation of HF generated from the UF_6. However, no fatalities occurred as a result of the toxicity of the uranium exposure. A few workers were exposed to amounts of uranium estimated to be approximately three times the guideline level used for assessing irreversible adverse effects (30 mg), but none of these workers actually experienced such effects (McGuire 1991).

For all of the management strategies considered in the PEIS, low-probability accidents involving chemicals at a conversion facility were estimated to have the largest potential consequences to noninvolved workers and members of the public. Conversion would be required for long-term storage as oxide, use as oxide, use as metal, and disposal. At a conversion site, accidents involving releases of chemicals, such as ammonia and HF, are possible. Ammonia is used for some conversion options, and HF can be produced in converting UF_6 to either uranium oxide or uranium metal. The primary impacts from conversion accidents are related to potential chemical exposures to the released material.

The conversion accidents estimated to have the largest potential consequences were accidents involving the rupture of tanks containing either anhydrous HF or ammonia. Such accidents could be caused by a large earthquake and are expected to occur with a frequency of less than once in 1 million per year of operations. The probability of these types of accidents occurring during the operation of a conversion facility would be about 1 chance in 50,000. If such accidents occurred, it was estimated that up to 41,000 members of the general public around the conversion facility and 1,100 noninvolved workers might experience adverse effects from chemical exposures (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). Of these, up to 1,700 members of the general public and 440 noninvolved workers might experience irreversible adverse effects (such as lung damage or kidney damage), with the potential for about 30 fatalities among the public and 4 fatalities among noninvolved workers. In addition, irreversible or fatal effects among involved workers are possible.

These high consequence accidents are expected to be extremely rare. The risk (defined as consequence multiplied by probability) for these accidents would be zero fatalities and irreversible adverse health effects expected for noninvolved workers and the members of the public combined, and one adverse health effect expected for the general public. Ammonia and anhydrous HF are commonly used chemicals for industrial applications in the United States. Industrial accident prevention and mitigative measures are well established for HF and ammonia storage tanks. These include storage tank siting principles, design recommendations, spill detection, and containment measures. These measures would be implemented, as appropriate, if conversion were required by the selected alternative.

Management of USEC-generated cylinders would not affect the accident consequences predicted for the DOE-generated cylinders (see Table 2.2), because, under all accident scenarios, only a limited amount of material would be at risk, regardless of the number of cylinders in storage. Frequencies for some facility accidents could increase. However, this increase would not be enough to change the overall expected frequency of specific accidents from the broad ranges used in the PEIS analysis.

2.4.3 Human Health and Safety — Transportation

A conservative estimate of transportation impacts was provided by assuming that continued cylinder storage, conversion, consolidated long-term storage, manufacture and use, and disposal facilities would be located at separate sites, requiring transportation of materials between these sites. Under the no action alternative, only small amounts of LLW and LLMW generated during cylinder maintenance activities would require transportation, with only negligible impacts expected. The major materials assumed to require transportation for the other alternatives are summarized in Table 2.2. Most materials could be shipped by either truck or rail. For purposes of comparison, it was assumed that all shipments would travel a distance of 620 miles (1,000 km), primarily through rural areas but including some suburban and urban areas. (Transportation impacts are evaluated for a range of shipment distances in Appendix J). Most shipments were assumed to occur over a 20-year period, from 2009 through 2028 (or through 2034 for management of USEC-generated cylinders). Impacts from transportation activities could be reduced if several facilities were located at the same site.

During normal transportation operations, radioactive material and chemicals would be contained within their transport packages. Potential health impacts to crew members (i.e., workers) and members of the general public along the route could occur if there were exposure to low-level external radiation in the vicinity of shipments of uranium materials. In addition, exposure to vehicle engine exhaust emissions could potentially cause adverse health effects from inhalation. Under all alternatives other than the no action and long-term storage as UF_6 alternatives, it was conservatively estimated that no more than one fatality would occur from these causes. Under all alternatives, members of the general public living along truck and rail transportation routes would receive extremely small doses of radiation from shipments, less than 0.1 mrem over 40 years. This would be true even if a single person were to be exposed to every shipment of radioactive material during the program.

Under all alternatives, traffic accidents could occur during the transportation of radioactive materials and chemicals. These accidents could potentially affect the health of workers (i.e., crew members) and members of the general public either from the actual accident or from accidental releases of radioactive materials or chemicals.

Under each alternative, the total number of traffic fatalities (unrelated to the type of cargo) was estimated on the basis of national traffic statistics for shipments by both truck and rail modes. For DOE-generated cylinders, if shipments were predominantly by truck, it was estimated that from two to four traffic fatalities could occur over the duration of the program. If shipments were predominantly by rail, it was estimated that one to two traffic fatalities could possibly occur. The actual number of fatalities would be much less if the number of shipments and shipment distances were reduced.

Severe transportation accidents could also cause a release of radioactive material or chemicals from a shipment. The consequences of such a release would depend on the material released, the location of the accident, and the weather conditions at the time. Potential consequences would be greatest in urban areas because more people could be exposed. Accidents that occurred when the weather was very stable (typical of nighttime conditions) would have higher potential consequences than accidents that occurred when the weather was unstable (i.e., turbulent, typical of daytime conditions) because the stability of the weather would determine how quickly the released material dispersed and diluted to lower concentrations as it moved downwind.

All alternatives other than the no action alternative could involve the transportation of UF_6 cylinders between sites. For cylinder shipments, among the accidents analyzed, a severe rail accident involving four cylinders was estimated to have the highest potential consequences. The consequences of such an accident would be highest if the accident occurred in an urban area under stable weather conditions (such as at nighttime). The total probability of an urban rail accident involving a release (not taking into account the frequency of weather conditions) was estimated to be about 1 chance in 10,000 for shipping all cylinders by rail (the actual probability would depend on the route selected). In the unlikely event that such an accident were to occur, it was estimated that approximately four persons might experience irreversible adverse effects (such as lung damage or kidney damage) from chemical exposure to HF and UO_2F_2 generated from released UF_6, with zero fatalities expected. Over the long term, radiation effects would be possible from exposure to the uranium released. It was estimated that approximately 60 cancer fatalities could occur in the urban population from such an accident in addition to the approximately 700,000 that would occur from all other causes (approximately 3 million persons were assumed to be exposed to low levels of uranium from the accident as the uranium dispersed in the air). The risk (consequence multiplied by probability) for this accident would be zero expected LCFs.

For all other materials assumed to be transported in the PEIS, the highest potential accident consequences would be caused by a rail accident involving anhydrous HF that might be produced during conversion. Conversion would be required for the long-term storage as oxide, use as oxide, use as metal, and disposal alternatives. Anhydrous HF is commonly transported by industry as a liquid in trucks and rail tank cars. Anhydrous HF could be produced during conversion and could potentially be transported to a user. Alternatively, the HF could be neutralized to CaF_2, a nontoxic solid, at the conversion site. The CaF_2 could also be transported to a user or shipped for disposal.

If a large HF release from a railcar occurred in an urban area under stable weather conditions, persons within a 7 mi^2 (18 km^2) area downwind of the accident site could potentially experience irreversible adverse effects from chemical exposure to HF. However, the probability of such an accident occurring if all the anhydrous HF produced was transported 620 miles (1,000 km) was estimated to be only about 1 chance in 30,000. Anhydrous HF is routinely shipped commercially in the United States for industrial applications. To provide perspective, since 1971, the period covered by DOT records, there have been no fatal or serious injuries to the public or to transportation or emergency response personnel as a result of anhydrous HF releases during transportation. Over that period, 11 releases from railcars have been reported that had no associated evacuations or injuries. The only major release (estimated at 6,400 lb of anhydrous HF) occurred in 1985 and resulted in approximately 100 minor injuries. The last HF release during transportation was a minor release in 1990. The improved safety record of transporting anhydrous HF in the past 10 years can be attributed to several practices. Such practices include installing protective devices on railcars, an overall decline in the number of derailments, closer manufacturer supervision of container inspections, and participation of shippers in the Chemical Transportation Emergency Center.

Nonetheless, if the unlikely rail accident described above (i.e., release of HF from a railcar in a densely populated urban area under stable weather conditions) were to occur, it was estimated that up to 30,000 persons might experience irreversible adverse effects (such as lung damage), with the potential for about 300 fatalities. If the same type of HF rail accident were to occur in a typical rural area, which would have a smaller population density than an urban area, potential impacts would be considerably less. In a rural area, it was estimated that approximately 100 persons might experience irreversible adverse effects, including one expected fatality. The weather conditions at the time of an accident would also significantly affect the expected consequences of a severe HF accident. The consequences of an HF accident would be much less under unstable weather conditions, the most likely conditions in the daytime. Unstable weather conditions would result in more rapid dispersion of the airborne HF plume and lower downwind concentrations. Under unstable conditions, an area of about 1 mi^2 (2 km^2) could be affected by an accident. If such an accident occurred in an urban area, approximately 3,000 persons were estimated to potentially experience irreversible adverse effects, with the potential for about 30 fatalities. If the accident occurred in a rural area under unstable weather conditions, 10 persons were estimated to potentially experience irreversible adverse effects, with zero fatalities expected. When considering the probability of an HF accident occurring, one person would be expected to experience irreversible adverse effects, and no fatalities would be expected over the shipment period.

Management of up to 15,000 USEC-generated cylinders would increase the total estimated number of fatalities from truck and rail accidents by about 30%. This increase would result in 0 to 1 additional fatality under each alternative. The total number of traffic fatalities would range from 2 to 4 for truck shipments and from 1 to 3 for rail shipments. Although exposures would also increase, no increase in the number of fatalities from radiological exposures or vehicle emissions during routine operations would be expected. The consequences of severe traffic accidents involving releases of radiation or chemicals would be the same as those for the shipment of DOE-generated cylinders, because the shipment sizes would be the same. The total probability of a severe accident would increase by about 30% as shipments continued for an additional 6 years. However, the risk (probability multiplied by consequence) results presented in Table 2.2 would stay the same.

2.4.4 Air Quality

For management of both DOE- and USEC-generated cylinders, air quality from construction and facility operations for all alternatives would be within existing regulatory standards and guidelines. All construction activities planned to support continued cylinder storage (e.g., constructing new storage yards) would be required within the first 10 years of continued storage when all cylinders would still be in storage under each alternative. Therefore, air quality impacts from construction activities at the current storage sites would be the same across the alternatives. Estimated concentrations of particulate matter (dust) that could be generated during construction activities are close to the regulatory standard levels; these temporary emissions could be controlled by good construction practices.

If it is assumed cylinder maintenance and painting activities would not reduce cylinder corrosion rates, it is possible that cylinder breaches could result in HF air concentrations greater than the regulatory standard level at the K-25 storage site around the year 2020; HF concentrations at the Paducah and Portsmouth sites were estimated to remain within applicable standards or guidelines (Tschanz 1997b). However, if continued cylinder maintenance and painting were effective in controlling corrosion, as expected, air concentrations of HF would be kept within regulatory standards at all storage sites (Tschanz 1997a).

2.4.5 Water and Soil

For operations under all alternatives, uranium concentrations in surface water, groundwater, and soil at the three current storage sites would remain below guidelines throughout the project duration (when the EPA proposed maximum contaminant level [MCL] of 20 µg/L for drinking water [EPA 1996] is used as a guideline for water and the EPA health-based residential soil guideline of 230 µg/g [EPA 1995a] is used as a guideline for soil). Under the no action alternative, if cylinder maintenance and painting would not reduce cylinder corrosion rates, it is possible that the uranium groundwater concentration could be greater than 20 µg/L at all three sites at some time in the future (earliest about the year 2100 at the Paducah site). However, if continued cylinder maintenance and painting were effective in controlling corrosion, as expected, groundwater uranium concentrations would remain less than 20 µg/L. For all other alternatives, groundwater concentrations would remain less than 20 µg/L, even without continued cylinder maintenance and painting, because the cylinders would begin to be removed around the year 2009.

Under the disposal alternative, if a disposal facility in a dry environmental setting were to fail, groundwater impacts would be unlikely for at least 1,000 years. (No measurable groundwater contamination would have occurred because of the small amount of rainfall and large distance to the groundwater table typical of a dry environment.) For a disposal facility in a wet environmental setting, the uranium concentration in groundwater beneath the facility might be greater than 20 µg/L within 1,000 years after failure of the facility (with or without consideration of USEC-generated cylinders). It should be noted, however, that the disposal calculations are subject to a great deal of uncertainty, and results would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were part of the management strategy selected. If disposal was implemented in the future, all disposal activities would take place in accordance with applicable rules and regulations for disposal of LLW.

Under all alternatives, construction activities have the potential to result in surface water, groundwater, or soil contamination through spills of construction chemicals. By following good engineering practices, concentrations in soil and wastewater (and therefore surface water and groundwater) could be kept well within applicable standards or guidelines.

Under the long-term storage as UF_6, long-term storage as oxide, and disposal as oxide alternatives, from 81,000 yd^3 to 2.6 million yd^3 (62,000 to 2 million m^3) of soil and rock could require excavation and surface disposal, depending on whether yards, buildings, shallow earthen structures, vaults, or a mine was selected. The excavated material could result in changes to topography at the facilities; these changes could be mitigated, if necessary, through trucking the excavated material off-site and/or by contouring and reseeding the site. Mine storage and disposal would generally result in the largest excavation volumes. If mine storage or disposal were selected as a UF_6 management strategy, excavation volumes could also be reduced through use of a previously existing mine.

Management of up to 15,000 USEC-generated cylinders would not affect the maximum groundwater concentrations of uranium at the current storage sites estimated for the DOE-generated cylinders only. Potential surface water, groundwater, and soil quality impacts at conversion, long-term storage, and manufacturing facilities would be site-dependent, but, on the basis of evaluations of representative and generic sites, contaminant concentrations would be expected to remain within guideline levels under all alternatives.

For disposal, the estimated groundwater concentrations of uranium during the post-closure (long-term) time frame could increase by about 20% when the potential impacts from management of the additional USEC-generated cylinders are included. This increase would not change the overall impact assessment (i.e., guidelines could be exceeded in a wet environment before 1,000 years, but they would not be exceeded in a dry environment for more than 1,000 years).

Under alternatives involving long-term storage or disposal, soil excavation volumes would increase by about 35% for some options when USEC-generated cylinders are included. The range of excavation requirements would increase to 100,000 to 3.6 million yd^3 (76,000 to 2.8 million m^3), depending on whether yards, buildings, shallow earthen structures, vaults, or a mine was the option selected.

2.4.6 Socioeconomics

The no action alternative would result in the smallest socioeconomic impacts of the alternatives considered, creating about 110 direct jobs and generating about $5.1 million in direct income per operational year. The storage as UF_6 alternative would have the second smallest socioeconomic impacts because conversion would not be required; this alternative would create about 570 to 1,200 direct jobs and generate about $33 to $66 million in direct income per year. The other alternatives (long-term storage as oxide, use as oxide, use as metal, and disposal as oxide) would have similar socioeconomic impacts, creating about 900 to 1,600, 1,200 to 1,600, 1,200 to 1,600, and 900 to 2,100 direct jobs per year, respectively, and generating about $53 to $85 million, $78 to $92 million, $78 to $92 million, and $55 to $120 million in direct income per year, respectively. Under the storage and disposal alternatives, the upper ends of the ranges of jobs created and income generated correspond to options requiring mine excavation.

Continued cylinder storage under all alternatives would result in negligible impacts on regional growth and housing. Such impacts would be site dependent, but would be minor for conversion and long-term storage based on the analysis for representative sites.

Management of up to 15,000 USEC-generated cylinders would increase the number of direct jobs and income at the Paducah and Portsmouth sites by about 30%. (Since no USEC-generated cylinders are located at the K-25 site, no change in socioeconomic impacts would occur at the K-25 site.) The annual impacts for conversion, manufacturing, and disposal facilities would be the same as those discussed for management of DOE-generated cylinders, but the period of operations would increase by about 6 years. For long-term storage and disposal facilities, the period of construction would also increase by about 6 years. Also, surveillance and maintenance impacts for long-term storage facilities would increase by about 30%.

2.4.7 Ecology

Habitat loss at the current storage sites for all alternatives would range from 0 to 7 acres (2.8 ha) for the no action alternative to 0 to 28 acres (11 ha) or less for all other alternatives, depending on whether cylinder transfer facilities at the three sites were selected as the cylinder preparation option. These habitat losses would constitute less than 1% of available land at the current sites and would have negligible impacts on biota.

New facilities would disturb from 30 to 40 acres (12 to 16 ha) for conversion, 96 to 144 acres (39 to 58 ha) for long-term storage as depleted UF_6, 75 to 210 acres (30 to 85 ha) for long-term storage as oxide, 90 acres (36 ha) for manufacturing, and 30 to 470 acres (12 to 190 ha) for disposal when only DOE-generated cylinders are considered. When both DOE- and USEC-generated cylinders are considered, the land disturbed would increase to a range of 110 to 170 acres (44 to 68 ha) for long-term storage as UF_6, 80 to 260 acres (32 to 100 ha) for long-term storage as oxide, and 40 to 590 acres (16 to 240 ha) for disposal. The large ranges in estimated land requirements result from the various options that could be selected; options involving disposal in a mine could require the largest amounts of land. The consequences of habitat loss would be site dependent in terms of adverse impacts to threatened and endangered species and wetlands, and they would be evaluated in subsequent site-specific NEPA reviews. As a general guideline, potential moderate adverse impacts to vegetation and wildlife from habitat loss were assumed if the required land area was greater than 10 acres, and potentially large adverse impacts were assumed if the required land area was greater than 100 acres.

If a disposal facility in a wet environmental setting were to fail, the uranium concentration in groundwater beneath the facility might exceed 20 µg/L within 1,000 years after failure. If the groundwater discharged to nearby surface waters, aquatic biota might be exposed to elevated concentrations of uranium, possibly resulting in adverse chemical effects; however, no adverse radiological effects would occur at the concentrations estimated. Concentrations would result in dose rates to aquatic organisms of less than 0.015 rad/d, less than 2% of the dose limit of 1 rad/d specified in DOE Order 5400.5.

Consideration of up to 15,000 USEC-generated cylinders would not significantly affect ecological impacts. Concentrations of uranium in soil, groundwater, or surface water would remain below benchmark values for toxic and radiological effects under all alternatives except the disposal alternative (in a wet environment). The adverse impact from disposal would be present whether or not the USEC cylinders were considered. Under alternatives involving long-term storage or disposal, additional habitat loss would result from additional land use requirements. However, the overall impacts assessment (i.e., negligible, moderate, or large impacts to vegetation or wildlife) would not change under any of the alternatives.

2.4.8 Waste Management

During continued storage at the current sites under all alternatives, LLMW would be generated from cylinder scraping and painting activities. The amount of LLMW generated from these activities could result in moderate impacts to waste management at the Paducah site (annual volumes could be about 23% of the current site annual LLMW generation volume of 100 m^3/yr); however, the amount is less than 1% of the current estimated annual LLMW treatment volume for all DOE facilities nationwide (i.e., 68,000 m^3/yr) and would have a negligible to low impact on DOE's waste management system as a whole.

The alternatives requiring conversion to oxide are long-term storage as oxide, use as oxide, and disposal as oxide. Depending on the conversion option selected, anhydrous HF or CaF_2 could be produced. Historical industrial experience indicates that anhydrous HF, if produced, would contain only trace amounts of depleted uranium (less than 1 ppm). Because of the considerable market for HF (it is commonly used for many industrial applications, including the production of UF_6 from natural uranium ore), it was assumed that if anhydrous HF was produced, it would be sold for use, subject to review and approval by DOE or NRC, depending on the specific use.

If an option involving CaF_2 production was selected, it is currently unknown whether CaF_2 generated in the conversion to oxide processes could be sold, whether the low uranium content would allow disposal as nonhazardous solid waste, or whether disposal as LLW would be required. The low level of uranium contamination expected (i.e., less than 1 ppm) suggests that sale or disposal as nonhazardous solid waste would be most likely. If sold for use, the use would be subject to review and approval by DOE or NRC, depending on the specific use. Waste management for disposal as nonhazardous waste could be handled through appropriate planning and design of the facilities. If the CaF_2 was considered to be LLW, the largest CaF_2 generation volumes (about 426,000 m^3 over the 20-year period for the conversion to oxide with neutralization of HF option) would represent about 10% of the projected DOE complexwide LLW disposal volume for approximately the same time period (i.e., 4.25 million m^3) and could result in moderate impacts on waste management (if the LLW was considered to be DOE waste).

Under alternatives requiring conversion to either oxide or metal, the empty cylinders would be treated to remove the heels material and crushed. It is assumed that the treated, crushed cylinders would become part of the DOE scrap metal inventory. If a decision on disposing of the crushed cylinders was made, the treated cylinders would be disposed of as LLW, representing a 3% addition to the projected DOE complexwide LLW disposal volume. This would constitute a low impact on DOE's waste management system as a whole.

Under the use as metal alternative, MgF_2 would also be produced during conversion. It is possible that the MgF_2 waste generated would be sufficiently contaminated with uranium to require disposal as LLW rather than as nonhazardous solid waste. (It is estimated that the MgF_2 would contain uranium at a concentration of about 90 ppm.) If the MgF_2 was considered to be DOE LLW, the volume generated would represent about 6% of the projected DOE complexwide LLW disposal volume, a low to moderate impact for DOE's waste management system as a whole. Under the metal conversion option, if the HF was neutralized and the CaF_2 generated was considered to be DOE LLW, the CaF_2 would represent approximately an additional 3% of the projected DOE complexwide LLW disposal volume, constituting a low to moderate impact on DOE's waste management system.

The LLW volumes requiring disposal under the disposal as oxide alternative represent an addition of from about 2 to 7% to the projected DOE complexwide LLW disposal volume, constituting a low to moderate impact for DOE's waste management system. The waste management impacts for all alternatives requiring conversion of UF_6 would be similar, having the potential for a moderate impact on DOE's LLW management system.

Consideration of up to 15,000 USEC-generated cylinders would not significantly affect waste management impacts. Total waste generation would increase by about 30% as a result of the operation of facilities for 6 additional years. However, the general waste management impacts under each alternative would be the same as those estimated for the DOE cylinders only. For example, waste management impacts, when considered with regard to national and regional waste management capabilities, would still be low to moderate under alternatives involving conversion and/or disposal, because of the potential disposal of CaF_2, MgF_2, empty cylinders, and depleted uranium oxide as LLW.

2.4.9 Resource Requirements

Resource requirements include construction materials, fuel, electricity, process chemicals, and containers. In general, all of the alternatives would have a negligible effect on the local or national availability of these resources (when both DOE- and USEC-generated cylinders are considered). However, under the long-term storage as UF_6, long-term storage as oxide, and disposal alternatives, options involving mine storage or disposal would require large quantities of electrical energy during construction (up to 1,100 MW-yr). The availability of this electricity would depend on site location. Also, the disposal alternative would result in permanent disposition of the depleted uranium, a material that DOE considers to be a valuable national resource. Disposal would constitute an irreversible and irretrievable commitment of this resource to a nonproductive purpose.

2.4.10 Land Use

For current sites, continued storage and cylinder preparation could require up to 28 acres (11 ha) of land for new or reconstructed cylinder yards and transfer facilities, if built. This acreage constitutes less than 1% of available land at the three sites. Furthermore, it is likely that previously developed land could be used for these needs.

New facilities would disturb from 30 to 40 acres (12 to 16 ha) for conversion, 96 to 144 acres (39 to 58 ha) for long-term storage as depleted UF_6, 75 to 210 acres (30 to 85 ha) for long-term storage as oxide, 90 acres (36 ha) for manufacturing, and 30 to 470 acres (12 to 190 ha) for disposal when only DOE-generated cylinders are considered. When both DOE- and USEC-generated cylinders are considered, the land disturbed would increase to a range of 110 to 170 acres (44 to 68 ha) for long-term storage as UF_6, 80 to 260 acres (32 to 100 ha) for long-term storage as oxide, and 40 to 590 acres (16 to 240 ha) for disposal. A protective action distance for emergency planning would need to be established around a conversion facility. This protective action distance would incorporate an area of about 960 acres around the conversion facilities. The large ranges in the estimated land required result from the various options that could be selected; options involving disposal in a mine could require the largest amounts of land. Potential land-use impacts would depend on where the facilities were sited. As a general guideline, potentially moderate land use impacts were assumed if the required land area was greater than 50 acres, and potentially large land use impacts were assumed if the required land area was greater than 200 acres.

2.4.11 Cultural Resources

Impacts to cultural resources at the current storage sites would be unlikely. Potential for impacts at new sites would depend entirely on their locations. Such impacts would be minimized through surveys conducted prior to construction activities and through consultation with state historic preservation officers.

2.4.12 Environmental Justice

No disproportionately high or adverse human health or environmental impacts would be expected to minority or low-income populations during normal facility operations for any of the alternatives (when both DOE and USEC-generated cylinders are considered). Although the consequences of facility accidents could be high if severe accidents occurred, the risk of irreversible adverse effects (including fatalities), among members of the general public from these accidents (taking into account the consequences and probability of the accidents) would be less than one. Furthermore, transportation accidents with high and adverse impacts are unlikely, their locations have not been projected, and the types of persons who would be involved cannot be reliably predicted; therefore, there is no reason to expect that minority and low-income populations would be affected disproportionately by high and adverse impacts.

2.5 DOE'S PREFERRED ALTERNATIVE

2.5.1 Description

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The preferred alternative would allow beneficial use of the material with regard to environmental, economic, technical, and other factors.

DOE's preferred alternative consists of the following elements: continuing the safe, effective management of the cylinders; beginning the prompt conversion of the depleted UF_6 into depleted uranium oxide and HF or CaF_2; storing depleted uranium oxide; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabricating depleted uranium oxide and metal products for use. Conversion to oxide or metal would also generate fluorine or fluorine compounds such as HF, which would also have beneficial uses. This preferred alternative provides the flexibility to respond to changing market conditions and to the continued development of new uses for the conversion products. During the time that the depleted UF_6 inventory is being converted for long-term storage and product applications, some depleted UF_6 would also be available for other uses that might develop.

Potential uses for fluorine products exist now in the aluminum, chemical, steel, and glass industries. Large-scale uses for the depleted uranium products are under development. These uses include radiation-shielding applications, in which uranium oxide is used as a substitute for the aggregate in concrete. Concrete made with depleted uranium would be a more effective shielding material than conventional concrete and would provide the same level of radiation shielding with less thickness than conventional concrete. Among other uses, this concrete could be fabricated into casks for storage of spent nuclear fuel or HLW.

In addition to the above potential large-scale uses of the depleted UF_6, small-scale use of some depleted UF_6 is being considered in industrial applications and by other DOE program decisions and NEPA analyses, such as that for the disposition of surplus plutonium (see Section 1.6). At this time, uses being considered by other DOE programs generally involve only a small fraction of the depleted UF_6 inventory currently in storage and would not affect the selection of a long-term management strategy in the Record of Decision to be issued following the publication of this PEIS.

DOE issued a Request for Expressions of Interest for a Depleted Uranium Hexafluoride Integrated Solution Conversion Contract and Near-Term Demonstrations on March 4, 1999 (U.S. Department of Commerce 1999). Responses to this request will provide DOE with information to develop a detailed procurement strategy for an integrated approach to the management of DOE's depleted UF_6 inventory. A final plan, incorporating information from the private sector and other stakeholders, is expected to be issued later in 1999.

The locations for conversion and fabrication facilities, the start-up date for conversion, the rate of conversion, and the chemical form of depleted uranium and fluorine products would be subject to follow-on (tiered) NEPA analyses and availability of any necessary federal funding. Conversion of the depleted UF_6 to uranium oxide under the preferred alternative would begin as early as practicable. DOE expects that in the future, uses will be available for some portion of the converted material. The value of depleted uranium and HF or CaF_2 for use is based on their unique qualities, the size of the inventory, and the history of uses already implemented (e.g., industrial applications for fluorine compounds). DOE plans to continue its support for the development of government applications for depleted uranium products and, for as long as is necessary, to continue the safe management of its depleted uranium inventory.

Current practices for managing the depleted UF_6 cylinder inventory include visual inspections, ultrasonic testing of cylinder wall thickness, radiological surveys, and surveillance and maintenance of the cylinders and cylinder yards. Under the preferred alternative, these practices would continue or be modified, as necessary, to meet any changing requirements for protection of worker and public health and safety and of the environment. Safe management of the cylinder inventory would continue through conversion of 100% of the inventory for use or storage. Aggressive cylinder management will ensure that continued storage of the depleted UF_6 cylinders prior to conversion will be consistent with DOE's policy of safe, effective material management.

2.5.2 Impacts of the Preferred Alternative

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. Most of the inventory would likely require interim storage as depleted uranium oxide pending use. The impacts of the 100% use as oxide alternative, 100% use as metal alternative, and 100% long-term storage as oxide alternative are described in detail in Sections 5.3, 5.4, and 5.5 for the DOE-generated cylinders. The impacts of adding the USEC cylinders under these alternatives are described in Sections 6.3.3, 6.3.4, and 6.3.5. The impacts of these three alternatives may be considered representative for the preferred alternative. To represent the impacts of a combination of use as oxide, use as metal, and storage as oxide, a strategy involving 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide was also analyzed. The potential impacts of this combination strategy are discussed in detail in

Section 5.7 and Section 6.3.7. A tabular summary of the potential impacts of this combination strategy that is representative of the preferred alternative is shown in Table 2.4.

For the four alternative management strategies considered representative of the preferred alternative (100% use as oxide; 100% use as metal; 100% long-term storage as oxide; and combination 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide), potential environmental impacts for many technical areas are very similar (see Tables 2.2, 2.3, and 2.4). With respect to human health and safety impacts of normal facility operations, the strategies have similar impacts; that is, radiological and chemical exposures for the general public and workers would remain well within regulatory limits and public health standards under all four strategies. Also, the consequences of accidents would be similar under all four strategies. Impacts to air quality, water and soil quality, and waste management would also be similar for the four management strategies representative of the preferred alternative.

Potential differences in impacts arise for the 25% use as oxide, 25% use as metal, 50% long-term storage as oxide combination strategy because of increased requirements for workforce, acreage, and construction and operational materials associated with the potential need for two conversion facilities, two manufacturing facilities, two cylinder treatment facilities, and a long-term storage facility. The resources required for these facilities are nonlinear with throughput; that is, the resources required to build and operate a 25%-capacity or a 50%-capacity facility are more than one-quarter or one-half the resources required to build and operate one 100%-capacity facility. This situation results in some increased impacts for the combination strategy. For example, the estimated number of worker fatalities and injuries for construction and operation under the combination strategy (3 to 4 fatalities; 2,200 to 3,100 injuries for the DOE-cylinders only) is about 1.5 times that estimated for the 100% use as oxide and 100% use as metal strategies, separately. Similarly, required jobs and income produced under the combination strategy are greater than they are under the 100% use strategies. If the combination strategy resulted in construction of separate conversion, manufacturing, cylinder treatment, and long-term storage facilities, total land use requirements could almost double, also resulting in an increased potential for adverse ecological impacts.

For the purposes of analysis of the combination strategy, it was assumed that independent conversion, manufacturing, and storage facilities would be constructed. However, in practice, such facilities may be located together, which would reduce the resource needs of the combination strategy.

The impacts of an additional combination use strategy (i.e., 50% use as oxide, 50% use as metal) are presented in Appendix K, Table K.10.

2.6 SUMMARY OF ISSUES RELATED TO POTENTIAL LIFE-CYCLE IMPACTS

All of the PEIS alternatives, except for disposal as uranium oxide, would require the continued management of depleted uranium beyond 2039, the time period addressed in detail in the

TABLE 2.4 Summary of Potential Environmental Consequences of a Combination Management Strategy Representative of the Preferred Alternative for DOE-Generated Cylinders Only and for the Total Cylinder Inventory[a]

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Normal Facility Operations[b]	
Radiation Exposure	
Involved Workers	
Annual dose to individual workers	Monitored to be maintained within maximum regulatory limit of 5 rem/yr or lower
Total health effects among involved workers (1999–2039)	1 to 2 additional LCFs [2 to 3 additional LCFs]
Noninvolved Workers	
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among noninvolved workers (1999–2039)	0 additional LCFs from routine site emissions
General Public	
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among members of the public (1999–2039)	0 additional LCFs from routine site emissions
Chemical Exposure of Concern (concern = hazard index > 1)	
Noninvolved worker MEI[c]	No (Hazard Index <1)
General public MEI	No (Hazard Index <1)
Human Health and Safety — Facility Accidents[b]	
Physical Hazards from Construction and Operations (involved and noninvolved workers)	
On-the-job fatalities and injuries (1999–2039)	3–4 fatalities; 2,200–3,100 injuries [4–5 fatalities; 2,900–4,100 injuries]
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites	
Likely Cylinder Accidents[d]	
Accident[e]	Corroded cylinder spill, dry conditions
Release	Uranium, HF
Estimated frequency	~ 1 in 10 years
Accident probability (1999–2039)	3 potential accidents [4 potential accidents]

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)	
Consequences (per accident)	
Chemical exposure – public	No adverse effects
Chemical exposure – Noninvolved workers[f]	
Adverse effects	70
Irreversible adverse effects	3
Fatalities	0
Radiation exposure – public	
Dose to MEI	3 mrem
Risk of LCF	1 in 1 million
Total dose to population	0.4 person-rem
Total LCFs	0
Radiation exposure – Noninvolved workers[f]	
Dose to MEI	77 mrem
Risk of LCF	3 in 100,000
Total dose to workers	2.2 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Low Frequency-High Consequence Cylinder Accidents[g]	
Accident[e]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse impacts)
Release	Uranium, HF
Estimated frequency	~ 1 in 100,000 years
Accident probability (1999–2039)	~ 1 chance in 2,500
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	1,900
Irreversible adverse effects	1
Fatalities	0
Chemical exposure – Noninvolved workers[f]	
Adverse effects	1,000
Irreversible adverse effects	300
Fatalities	3
Radiation exposure – public	
Dose to MEI	15 mrem
Risk of LCF	7 in 1 million
Total dose to population	1 person-rem
Total LCFs	0

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)	
Radiation exposure – Noninvolved workers[f]	
Dose to MEI	20 mrem
Risk of LCF	8 in 1 million
Total dose to workers	16 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[g]	
Chemical accident[e]	HF or NH_3 tank rupture
Release	HF, NH_3
Accident location	Conversion site
Estimated frequency	< 1 in 1 million years
Accident probability (1999–2039)	1 chance in 50,000
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	41,000
Irreversible adverse effects	1,700
Fatalities	30
Chemical exposure – noninvolved workers[f]	
Adverse effects	1,100
Irreversible adverse effects	440
Fatalities	4
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Radiological accident[e]	Earthquake damage to storage building at conversion site
Release	Uranium (U_3O_8)
Accident location	Conversion site
Estimated frequency	1 in 100,000 years
Accident probability (1999–2039)	1 chance in 5,000

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[g] (Cont.)	
Consequences (per accident)	
Radiation exposure – public	
Dose to MEI	270 mrem
Risk of LCF	1 in 10,000
Total dose to population	20 person-rem
Total LCFs	0
Radiation exposure – noninvolved workers[f]	
Dose to MEI	9,000 mrem
Risk of LCF	1 in 250
Total dose to workers	840 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 LCFs
Noninvolved workers	0 LCFs
Human Health and Safety — Transportation[b]	
Major Materials Assumed to Be Transported between Sites	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks
Normal Operations	
Fatalities from exposure to vehicle exhaust and external radiation	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo)	
Maximum use of trucks	4 fatalities [5 fatalities]
Maximum use of rail	1 fatality [2 fatalities]

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Transportation[b] (Cont.)	
Traffic Accidents Involving Releases of Radiation or Chemicals	
Low Frequency-High Consequence Cylinder Accidents	
Accident	Urban rail accident involving 4 cylinders
Release	Uranium, HF
Accident probability (1999–2039)	1 chance in 10,000
Consequences (per accident)	
Chemical exposure –All workers and members of general public	
Irreversible adverse effects	4
Fatalities	0
Radiation exposure – All workers and members of general public	
Total LCFs	60
Accident Risk (consequence times probability)	
Workers and general public	0 fatalities
Low Frequency-High Consequence Accidents with All Other Materials	
Accident	Urban rail accident involving anhydrous HF
Release	Anhydrous HF
Accident probability (1999–2039)	1 chance in 30,000
Consequences (per accident)	
Chemical exposure – workers and members of general public	
Irreversible adverse effects	30,000
Fatalities	300
Accident risk (consequence times probability)	
Irreversible adverse effects	1
Fatalities	0
Air Quality	
Current Storage Sites	
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites
Other Facilities[h]	
Pollutant emissions during construction and operations	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Water and Soil[i]	
Current Storage Sites	
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels
Other parameters[j]	No change
Other Facilities[h]	
Surface water, groundwater, and soil quality	Site-dependent; contaminant concentrations could be kept within guideline levels
Other parameters[j]	Site-dependent; none to moderate impacts
Excavation of soil for long-term storage	Change in topography from 41,000 yd^3 to 1.1 million yd^3 of excavated material [51,000 yd^3 to 1.3 million yd^3]
Socioeconomics[k]	
Current Storage Sites	
Continued storage	**Jobs:** 30 peak year, construction; 120 per year over 20 years of operation [150 per year over 26 years of operation] **Income:** \$1.4 million peak year, construction; \$6 million per year over 20 years of operation [\$7 million per year over 26 years of operation]
Cylinder preparation	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 20 years of operation [over 26 years of operation] **Income:** \$0–26 million peak year, preoperations; \$19–25 million per year over 20 years of operation [over 26 years of operation]
Other Facilities[h]	
Conversion	**Jobs:** 670–960 peak year, construction; 510–720 per year over 20 years of operation [over 26 years of operation] **Income:** \$28–41 million peak year, construction; \$30–41 million per year over 20 years of operation [over 26 years of operation]

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Socioeconomics[k] (Cont.)	
Manufacturing	**Jobs:** 270 peak year, construction; 430 per year over 20 years of operation [over 26 years of operation]
	Income: $13 million peak year, construction; $30 million per year over 20 years of operation [over 26 years of operation]
Long-term storage	**Jobs:** 60–210 peak year, construction; 30–35 per year over 30 years of operation [39–46 per year over 30 years of operation]
	Income: $3–10 million peak year, construction; $2–3 million per year over 30 years of operation [$3–4 million per year over 30 years of operation]
Ecology	
Current Storage Sites	
Habitat loss[l]	Up to 28 acres; negligible to potential moderate impacts
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	None to negligible impacts
Other Facilities[h]	
Habitat loss[l]	**Conversion:** Up to 30 acres at a single site; total of up to 50 acres; potential moderate impacts to vegetation and wildlife
	Manufacturing: Up to 79 acres at a single site; total of 160 acres; potential moderate impacts to vegetation and wildlife
	Long-term storage: About 49 acres; potential moderate impacts to vegetation and wildlife [About 61 acres]
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Site-dependent; avoid or mitigate

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
	Waste Management
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (increase of about 20%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation [increase of about 30% in LLMW at Paducah site]
Other Facilities[h]	
Conversion	Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) and MgF_2 as LLW (if required); potential moderate impact to site waste generation for CaF_2 and MgF_2 as nonhazardous solid waste
Manufacturing	Negligible impacts with respect to current regional or nationwide waste generation
Long-term storage	Negligible impacts with respect to current regional or nationwide waste generation
	Resource Requirements[m]
All Sites	No effects on local, regional, or national availability of materials are expected; impacts of electrical requirements for mine excavation depend on site location
	Land Use
Current Storage Sites	Up to 28 acres; less than 1% of available land; negligible impacts
Other Facilities[h]	
Conversion	Up to 30 acres at a single site; total of up to 50 acres; potential moderate impacts
Manufacturing	Up to 79 acres at a single site; total of 160 acres; potential moderate impacts
Long-term storage	About 49 acres; potential moderate impacts [About 61 acres]

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
	Cultural Resources
Current Storage Sites	Impacts unlikely
Other Facilities[h]	Impacts depend on location; avoid and mitigate
	Environmental Justice
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely

[a] In general, the overall environmental consequences from managing the total cylinder inventory (total of USEC-generated and DOE-generated cylinders) are the same as those from managing the DOE-generated cylinders only. In this table, when the consequences for the total inventory differ from those for the DOE-generated cylinders only, the consequences for the total inventory are presented in brackets following the consequences for DOE cylinders only.

[b] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

[c] Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[d] Accidents with probabilities of occurrence greater than 0.01 per year.

[e] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[f] In addition to noninvolved worker impacts, involved worker injuries and fatalities are possible from chemical, radiological, and/or physical forces of accidents. Chemical and radiological exposures for involved workers (workers within 100 m of a release) under accident conditions would depend in part on facility designs and other factors (see Section 4.3.2.1).

[g] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[h] Other facilities are facilities for conversion, manufacturing, and storage.

[i] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed U.S. Environmental Protection Agency (EPA) maximum contaminant level of 20 µg/L (EPA 1996); this value is an applicable standard for water “at the tap” of the user and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 µg/g.

[j] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

Footnotes continue on next page.

TABLE 2.4 (Cont.)

Footnotes (Cont.)

[k] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages, except for continued storage, which is reported for the peak year of operations.

[l] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

[m] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; PM_{10} = particulate matter with a mean diameter of 10 µm or less; UF_6 = uranium hexafluoride.

PEIS. The potential environmental impacts of management activities beyond 2039 were not evaluated in the PEIS because the specific actions that would take place are considered highly uncertain and speculative and are not ready to be decided upon at this time. A discussion of issues related to the potential life-cycle impacts associated with depleted uranium management is provided in Section 5.9 and summarized here.

The management of depleted uranium beyond the year 2039 would depend on the management strategy in place at that time. If depleted uranium were in long-term storage in 2039, the depleted uranium could continue to be stored, it could be used or disposed of, or it could be converted to another chemical form and then used or disposed of. Continued storage may require refurbishment or replacement of facilities and containers as their design lifetimes are exceeded.

Depleted uranium might also require management after use, depending on the type of product and nature of the use. After use, products containing depleted uranium could potentially be stored, reused, recycled for other uses, or treated and disposed of as LLW. The ultimate fate of the depleted uranium after use would depend in part on market demand, economic considerations, and the applicable regulatory requirements at that time. Disposal after use may also require further treatment or processing, such as conversion to a suitable chemical form. Some uses might also result indirectly in the permanent disposal of the material. For example, it is possible that casks containing depleted uranium could be used as part of a disposal package for spent nuclear fuel or HLW in a geologic repository.